A SCHOOL COURSE IN

HYGIENE

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BEING AN ADAPTATION FOR SCHOOL USE OF
"A FIRST COURSE IN HYGIENE"

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PREFACE

One of the most remarkable developments of recent years is the enormous growth of public interest given to the subject of hygiene, and the consideration of the laws and circumstances affecting the health of the individual and the community. It is now realised generally that such knowledge does not constitute a branch of learning which should be restricted to the medical profession, but that it is of vital importance to the general public, and constitutes an essential item in the educational equipment of our boys and girls. Simple facts relating to the preservation of health and the prevention of disease, together with the elementary scientific principles upon which the laws of health are founded, can be readily understood and appreciated by all.

The recognition of the above facts and the increasing popularity of the subject with teachers and students in various types of schools, together with the pressing need for a book specially adapted to such readers, a book which expounds and illustrates the laws of health in a simple manner, have led to the publication of this little book.

The book is based upon the author's *First Course in Hygiene*, from which the more advanced portions have been eliminated and the remainder specially prepared for use with junior pupils in schools. It retains, however, those distinctive features which have always made that book a great favourite with teachers and students alike.

The author's *First Course in Hygiene* was the first publication which presented the necessary human anatomy and physiology together with the hygiene and public health as associated and dependent parts of a whole instead of two distinct and separate sections. In this book that system has been

continued, the various physiological sections being introduced as required according to their bearing on the various sections of hygiene. At the same time the amount of physiology and anatomy which has been introduced is only such as is absolutely essential to the intelligent study, by junior pupils, of the hygiene included in the book. Technical terms have been reduced to a minimum and only those have been introduced which may now be regarded as part of the necessary equipment of the average educated person.

Another feature in connection with which the *First Course in Hygiene* acted as a pioneer was the introduction of practical work at the ends of various chapters in which the subject-matter was suitable for such treatment. This feature has been continued in the present book, in which the experiments introduced are all of a simple character and should be performed by the student, as they illustrate, emphasise, and explain essential principles.

NOTE TO THE SECOND EDITION

For this new edition the type has been reset, various alterations and additions have been made to the text, and some new diagrams have been prepared. A distinctive new feature is the guide to the pronunciation of scientific terms given at the end of the book.

The opportunity has also been taken to revise the sections on artificial respiration, and our grateful thanks are due to the Royal Life Saving Society for permission to incorporate their official instructions, and also for the loan of Figs. 71, 72, 73, 74.

ROBERT A. LYSTER.

London, June 1935.

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A SCHOOL COURSE IN HYGIENE

CHAPTER I

THE GENERAL BUILD OF THE BODY

1. Anatomy and Physiology

For the intelligent study of **Hygiene** or **Health-science** it is necessary that the student should become acquainted with a certain definite amount of elementary **Human Anatomy** and **Physiology**. By Anatomy we mean the study of various parts of the body; and the study of the work which these parts have to do is known as Physiology.

As far as possible we shall consider such subjects in direct connection with those portions of Hygiene that are concerned with the healthy performance of the work of special organs of the body. In other words we shall first study the structure and the work of some parts of the body, and then consider the hygienic conditions under which this part discharges its functions in the best possible way.

Before any special organs can be considered it is necessary to make ourselves acquainted with the general structure of the body, the bony framework or skeleton, and the general arrangement of the internal organs.

The simplest division of the body is into *hard parts*, comprising the cartilage and bones, and *soft* or *fleshy parts*.

THE HARD PARTS

2. The Skeleton

The skeleton or bony framework of the body serves a double purpose. Primarily it is the support of the soft parts, and serves to give the body a definite shape or build. Further, it affords special protection to highly important structures and

organs. Thus the skull and vertebral column or back bone serve as a protection for the brain and spinal cord, and the ribs form a bony framework for the protection of the heart and lungs. In the sections which follow (Sects. 3-10) the more important parts of the skeleton are briefly considered.

3. The Skull

Balanced on the top of the vertebral column (Sect. 4) is the

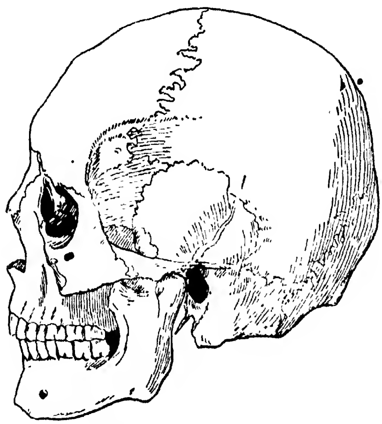

Fig. 1. SKULL (Side view).

skull. It may be divided into two parts: (i) the **cranium**, and (ii) the **face bones.**

(i) THE CRANIUM.—The cranium is a bony box for the brain. It is made up of eight bones very strongly bound together. The bones forming the base are very rough and irregular, while the front, back, roof, and sides are formed of smooth convex bones. Leading into the skull are several openings, one large, and the remainder comparatively small. The large

opening—the **foramen magnum**—serves for the passage of the spinal cord (Sect. 15) from the brain into the canal provided for it in the vertebral column. Close to this large opening, one on each side, are two smooth surfaces or **facets**, which rest upon two similar surfaces on the first vertebra. In the action of nodding these smooth surfaces glide upon each other. Through the smaller openings in the base of the skull pass the cranial nerves from the brain to the various parts of the head and face and also to some important structures and organs.

(ii) THE FACE BONES.—The face is made up of fourteen bones, thirteen of which are closely bound to each other or to the bones of the cranium. The fourteenth or lower jaw bone is fastened only at each end and can be moved about more or less like a door upon hinges.

4. The Back Bone

The **vertebral**, or **spinal**, **column** is the chief support of the trunk. It consists of thirty-three bones which are so tightly fastened together that only a very small amount of movement can take place between any vertebra and its neighbour. Taken as a whole, however, the vertebral column can perform very wide movements, and these are capable, by practice when young, of extraordinary developments, as is evidenced by the contortions of the so-called " boneless men."

Of these thirty-three bones which make up the vertebral column the upper twenty-four are always quite separate and distinct from each other, but in place of the lower nine vertebrae there are only two bones in the adult. Five of these nine vertebrae have united together to form a large strong bone called the **sacrum**. This is a wedge-shaped bone with the narrow end below, like the keystone of an arch. To it are fastened the hip bones, one on each side (Sect. 8). The four lowest vertebrae have united together, and are represented by a small bone—**the coccyx**, which is attached to the bottom of the sacrum. The coccyx is the rudimentary

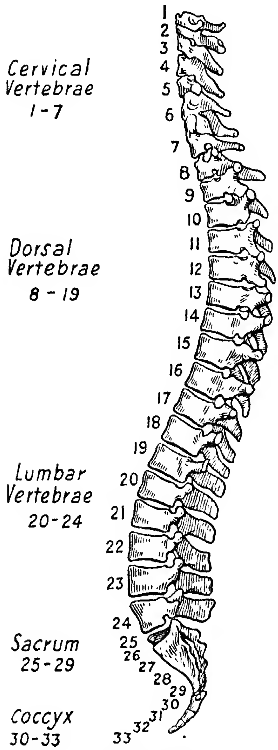

Fig. 2. The Vertebral Column or Back Bone.

tail in the human body. In animals these vertebrae remain distinct. They may be very numerous and form a long, flexible tail.

The upper twenty-four vertebrae are divided into three regions:—

(1) The Neck (Cervical Vertebrae—Seven).

(2) The Back (Dorsal Vertebrae—Twelve).

(3) The Loins (Lumbar Vertebrae—Five).

Viewed sideways the cervical region forms a curve with the hollow facing backwards, the dorsal region another facing the opposite way, the lumbar region another facing backwards, and the sacrum and coccyx form another facing forwards. The vertebrae are bound together by ligaments and by *intervertebral discs* of cartilage. These discs also act as buffers in preventing shocks and jars reaching the brain just like railway carriages are protected from shock by the buffers.

The proper curves of the spine are maintained by muscles whose action is sustained by suitable exercises and correct

postures. Slack habits, improper desks, weakness of muscles, and other causes may distort the spine and produce unnatural curves. Viewed from the back the spine should show a straight line. A lateral curvature may easily be produced by bad postures or by a disease called rickets.

5. The Ribs and the Breast Bone

The dorsal vertebrae at the back, and the **sternum** or breast bone in front, together with the curved bones connecting them, **the ribs**, constitute the bony cage called the **thorax**. There are twelve pairs of ribs. Each pair is attached to a dorsal vertebra, one on each side of it, and the joints by means of which the ribs are attached allow movement to take place up and down. This movement takes place at every breath.

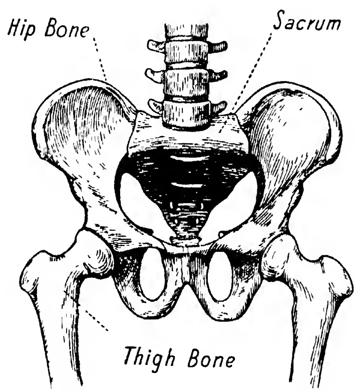

Fig. 3. SACRUM AND HIP BONES.

The first ten pairs of ribs are attached in front to the sternum by means of bands of gristle—the **costal cartilages**—the first five pairs having separate connecting bands, while the second five are united to a single cartilage—the sixth. The last two pairs of ribs, the eleventh and twelfth, are not attached in front at all, and are therefore called **floating ribs**. These are easily pressed inwards by tight lacing.

The sternum or breast bone is about six inches long and is flat and shaped more or less like a dagger, being broader above than below.

Viewed as a whole, the bony thorax is of a conical shape, being broader below than above. The intervals between the ribs are called **intercostal spaces,** and are filled up by muscles called the **intercostal muscles.**

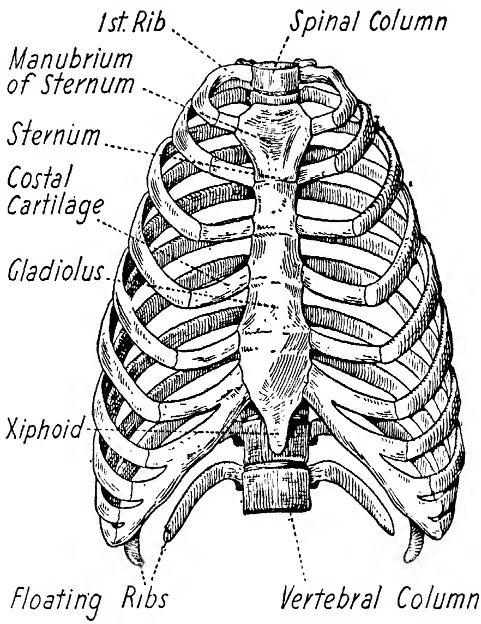

Fig. 4. The Bony Thorax.

Stand in front of a looking glass and watch your bare chest during deep breathing. Notice how the muscles pull the ribs upwards during inspiration thereby causing them to project farther outwards and so enlarging the capacity of the thorax.

6. The Shoulder Bones

From the top of the breast bone, on each side, you can feel your **collar bone** connecting the breast bone to the shoulder. The collar bone, or **clavicle,** is curved like the italic *f*, and extends outwards and backwards to the shoulder, where it is fastened to the outer part of the **shoulder blade.** The outline of the collar bone can be felt distinctly beneath the skin. The shoulder blade or **scapula** is a triangular flat bone which lies on the upper ribs, at the back of the thorax. The outline of this bone can be felt beneath the skin. It is not directly connected with the thorax. The shoulder end of the scapula is smooth and hollowed, and forms with the top of the arm bone the shoulder joint. Each shoulder is, therefore, made up of a collar bone, a shoulder blade, and an arm bone.

Fig. 5. The Collar Bone.

The shoulder joint possesses great mobility, the arm being easily moved forwards, backwards, upwards, and downwards, in addition to being rotated. This great mobility is due mainly to the shallowness of the depression in the scapula, and to the numerous and powerful muscles that act upon the joint.

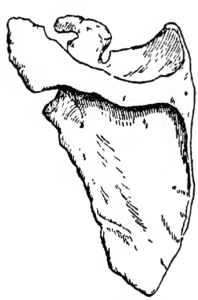

Fig. 6. The Left Shoulder Blade.

7. The Upper Limbs

The arm bone or **humerus** has a large rounded upper end—the head, which enters into the formation of the shoulder joint. The lower end is flattened, and meets the two bones of the forearm at the elbow joint which is like a hinge. The bones of the forearm are the **radius** (on the thumb side of the arm) and the **ulna.** These bones are easily traced in your

own arm. The bony point of the elbow is the head of the ulna. The wrist bones (**carpals**) are eight small bones arranged in two rows of four: the hand bones (**metacarpals**) are the five long narrow bones easily felt at the back of the hand. Attached to the hand bones are the small finger bones (**phalanges**), each finger having three and the thumb two.

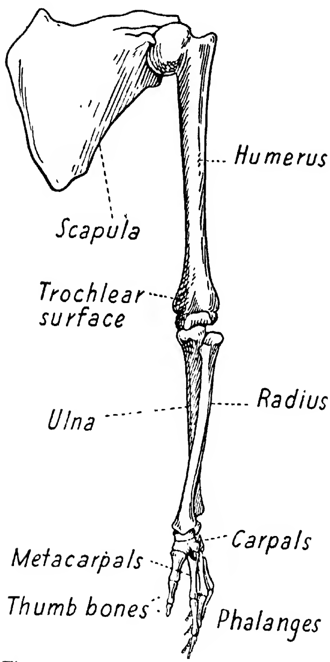

Fig. 7. The Shoulder and Arm Bones.

8. The Hip Bones

On each side of the sacrum is fastened a strong irregularly shaped bone, the **hip bone.** The top edge of these bones is obvious below the waist on each side. These bones prevent the waist bands from slipping down.

From the sacrum the hip bones curve outwards and then forwards and downwards, finally meeting each other in front. The parts meeting in front are called the **pubic bones.** The hip bones inclose a basin-shaped cavity called the **pelvic cavity.** The two hip bones, together with the sacrum and coccyx, form a bony girdle called the **pelvis** (Fig. 3).

9. The Lower Limbs

The outer side of the hip bone contains a rounded cavity for the reception of the ball-shaped head of the **femur** or **thigh bone.** The thigh bone is long and strong. The lower end forms part of the knee joint. The other part of the knee is formed by the **shin bone** or **tibia,** while in front of the joint is the small rounded bone called the **kneecap** or **patella,** which is held in position by a strong tendon. On the outer side of the tibia is a long thin bone—the **fibula.** Seven ankle bones (**tarsals**) form the ankle and heel.

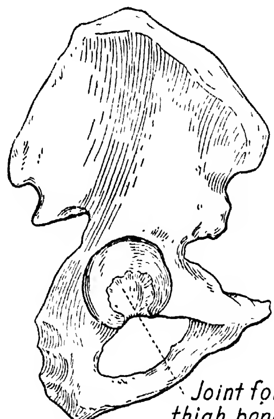

Fig. 8. THE RIGHT HIP BONE.

10. The Feet

The **foot** is narrowest at the heel and broadens towards the toes. The bones of the foot form two arches, one from heel to toes, the other transverse from side to side. These arches give elasticity and strength to the foot. The arching of the foot, together with the great number of its joints and the excellent leverage obtained by the muscles of the calf which pull on the heel bone in raising the body on tip-toe, renders the foot adaptable to walking. If the arch collapses the painful condition called flatfoot is produced. The imprint of a wet foot should show the extent of the arch (Fig. 10). Flatfoot is common among ill-fed and weakly children. The five foot bones are called **metatarsals,** the toe bones (two in the big toe and three in each of the others) **phalanges,** all arranged in the same way as in the hands.

11. The Joints

The various **joints** are formed where bones meet. If the joint admits of movement it is called a **movable joint**, but a joint where the bones are immovable is said to be a **fixed joint.** The bones of the skull are locked immovably together by their serrated edges. Some joints, such as those between each vertebra and its neighbours, consist only of a thick disc of cartilage between the adjacent bones. The movement in such joints is small.

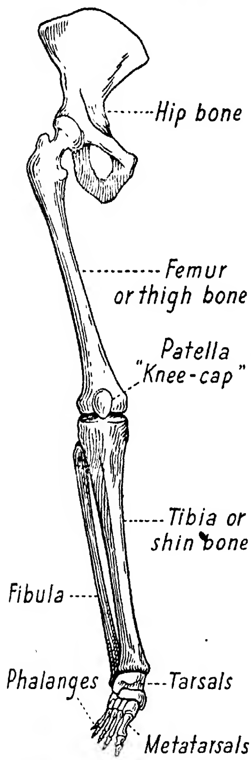

Fig. 9. Hip Bone and Right Leg.

Other joints, such as the hip, knee, and shoulder, allow great freedom of movement, and are formed by the contact of the smooth polished surfaces of the adjacent bones. These surfaces are covered with a thin layer of softer material called gristle or cartilage, and the joint is shut in by a loose bag called the **capsule.** The capsule is lined by a smooth glistening membrane kept moist by a liquid called synovial fluid. Such joints are strengthened by tough bands of white flexible material called ligaments, which pass over the joint, from bone to bone, and serve to limit excessive movement.

THE SOFT PARTS

12. Different Organs or Systems

The soft parts of the body are divided into different **organs** and **systems.** Each system is devoted to some special work which is called its *function.* The chief systems are:—

(1) The *nervous system,* which includes the brain, spinal cord, and all the nerves. This system controls all the ordinary working of the body.

(2) The *muscular system,* which effects the movements.

(3) The *alimentary system,* which includes the stomach,

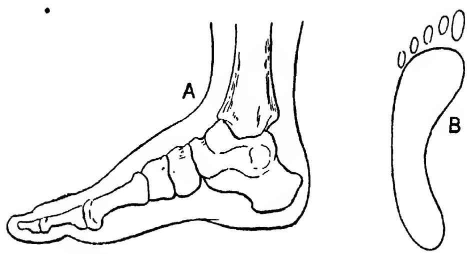

Fig. 10. A, The Foot; B, Imprint of Foot.

intestines, etc.; its function is to digest the food and hand over the nourishment to the blood.

(4) The *circulatory system,* which is concerned with the conveyance of this nourishment in the blood to every part of the body. This is done by the heart and blood vessels, which also serve to convey oxygen in the blood from the lungs to all parts of the body.

(5) The *excretory system,* which includes the lungs, skin, and kidneys. These get rid of impurities or waste products of the body which are brought to the excretory organ dissolved in the blood. The lungs have an additional function: they bring oxygen into the blood.

The various systems are composed of several different materials or **tissues.** Amongst these we have the epithelial, the connective, the muscular, the fatty, and the nervous tissues. Most of these tissues are found in each system. When a tissue is examined under the microscope it is found to consist of a number of units called **cells**; one tissue differs from another in the nature of its cells, and in the way in which these cells are connected. In a living animal these cells consist mainly of a substance called **protoplasm.**

13. The Nervous System

The nervous system is the most important of all the parts of the body, and is the most complicated and highly organised. By means of it we think, exercise our will and our various senses (sight, touch, smell, etc.), control the movements of the body, and carry on automatically various acts and processes such as the beating of the heart and the passing of the food along the intestines.

The brain and the spinal cord constitute the **central nervous system,** while the nerves connected with them are collectively called the peripheral portion of the nervous system. The whole system is made up of nerve cells and nerve fibres. Each nerve fibre is connected with a nerve cell. The nerves are bundles of nerve fibres lying side by side and bound firmly together. Masses of nerve cells have a grey appearance and are described as "grey matter," while the bundles of nerve fibres, being much paler, are called "white matter."

14. The Brain

The brain is a large light-grey organ weighing about 50 ounces and almost entirely filling the cavity of the skull. It commonly measures 7 inches in length and 5 inches in width. It is covered with three membranes which, together with the skull, afford it great protection. The surface is much folded. From the under side of the brain twelve white bands issue These are the cranial nerves (Sect. 16).

15. The Spinal Cord

The brain is continuous downwards with the soft whitish mass which passes through the foramen magnum and fills the cavity of the vertebral column as far as the second lumbar

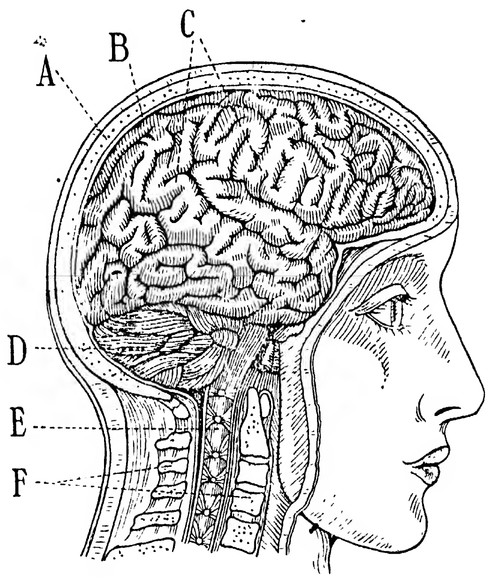

Fig. 11. Diagram Showing the Brain and Upper Part of Spinal Cord Exposed in Natural Position.

A = Bone of skull. B = Membrane surrounding brain (dura mater). C = Convolutions of brain (cerebrum). D = Cerebellum. E = Spinal cord. F = Vertebrae (cut through).

vertebra, where it ends in a bundle of nerves. This elongated mass of nervous tissue, the continuation downwards of the brain, is the spinal cord, or spinal marrow.

16. The Nerves

Twelve pairs of **cranial nerves** emerge from the under side of the brain. These find their way through various holes in the base of the skull and are distributed to various parts of the head, neck, and upper part of the body. Similarly the spinal cord gives off white strands in pairs, one on each side, called **spinal nerves, thirty**-one pairs in all. Each nerve leaves the cord by two roots which join together while still in the spinal canal. Each nerve then leaves the spinal canal by a small opening between the vertebrae. Outside the vertebral column they join together in a complicated fashion, and from the networks so formed various large nerves arise. These are distributed to all parts of the body.

A nerve is often described as a telegraph wire. Messages or impulses are transmitted along nerves to or from the brain, or to or from the spinal cord. Nerve fibres that bring impulses *to* the brain or spinal cord are called **afferent** or **sensory nerves**, because it is by means of such fibres that we acquire our knowledge of the world through sight, touch, hearing, smell, etc. On the other hand the nerves conveying impulses *from* the brain or spinal cord are called **efferent** or **motor nerves**, because the impulses result in the contraction of a muscle and so cause movement.

17. The Muscles

The various joints allow the bones of the body to be bent in many directions. Of themselves, however, the bones cannot perform any movement, but all movements are accomplished by the contraction of **muscles.** The muscles of animals constitute the chief part of the flesh of the body, and are the lean part of the " meat."

Passing to each muscle is a nerve which conveys to it the messages from the brain or spinal cord. This, as already indicated, is called a motor nerve; if it is cut or damaged the muscle becomes paralysed and incapable of producing any movement.

Muscles are usually divided into two classes: (1) the **voluntary muscles,** (2) the **involuntary muscles.**

The voluntary muscles are those muscles whose movements are under the control of the will. The two ends of such a muscle are commonly attached to two bones with a joint between them. When the muscle contracts it bends the joint. When the joint is bent it may be straightened out again by the contraction of another muscle, which tends to bend the joint in the opposite direction. For instance, the biceps muscle of the arm is attached to the scapula at the shoulder, and to the radius just below the elbow. When it contracts it pulls up the forearm and so bends the elbow.

The involuntary muscles are those which act independently of the will. They form the muscular walls of the stomach, intestines, bladder, heart, and blood vessels, where the body's work is carried on without control by the will.

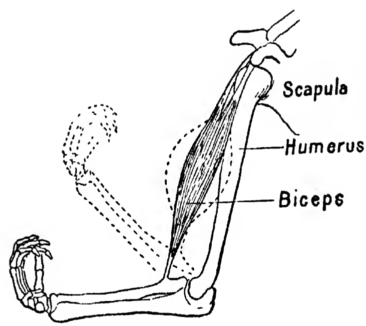

Fig. 12. The Action of the Biceps Muscle.

Our voluntary movements are usually produced by a muscle or a set of muscles using a bone as (what is called in everyday life) a **lever.**

A lever is a rigid bar which is capable of being moved about a fixed point. This fixed point (the part of the lever which remains stationary all the time) is called the *fulcrum.* The force producing the motion is generally called *power*, and the body which is being moved by the lever is referred to as the

weight. These three, the fulcrum, the power, and the weight, may be arranged along the bar in three different relative positions, giving three orders of levers.

A lever of the *first order* is where the power and the weight act with the fulcrum between them, as in a pair of scissors or an ordinary lever. This form of lever is used when we nod our head. A set of muscles pulls down the head in front, and another set pulls down at the back, the fulcrum being the point at which the skull rests on the first cervical vertebra.

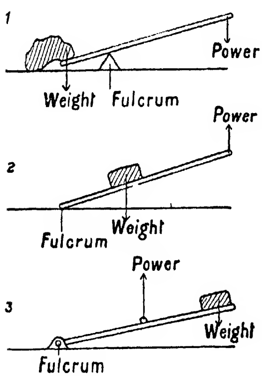

Fig. 13. Levers.
1. First Order. 2. Second Order. 3. Third Order.

The *second order* of levers is where the fulcrum is at one end of the lever and the power at the other end, with the weight between them, as in a pair of nut-crackers or a wheel-barrow. This is the position when the body is raised on tip-toe. The force here is represented by the muscles at the back of the leg, which are pulling up the heel. The weight of the body acts in the middle, and the toes form the fulcrum.

A lever of the *third order* is exemplified by a pair of sugar tongs or coal tongs. The contraction of the biceps producing movement of the forearm also illustrates a lever of this order. The fulcrum is the elbow joint. The power is the contracting biceps, and is applied about an inch away from the elbow. The weight acts further down and is represented by the arm which is lifted.

By using bones as levers in one of these three ways most of the movements of the body are performed.

THE BODY TRUNK

18. Divisions of the Body Cavity

The limbs are practically solid structures, composed of the tissues previously mentioned. The **trunk**, on the other hand, is hollow. This space inside the trunk is called the **body cavity.** At about the level of the three lowest ribs is an arched muscular partition, which divides the body cavity into two distinct parts, an upper part called the **thorax** or **chest**, and a lower part called the **abdomen.**

19. The Thorax and its Contents

This cavity is bounded *in front* by the sternum and the cartilages of the ribs; *at the sides* by the ribs and the intercostal muscles between them; *behind* by the ribs, vertebral column, and the great muscles of the back; *above* by the first rib, the collar bone, and the neck; *below* by the arched muscular partition called the **diaphragm.**

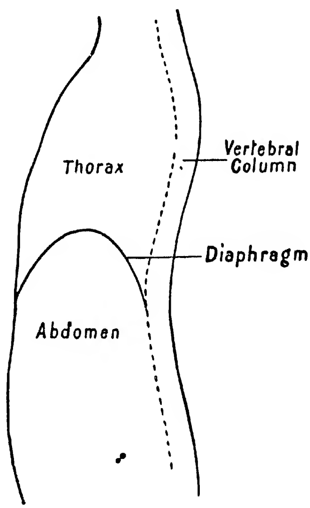

Fig. 14. The Body Cavity.

It is convenient to divide the contents of the thorax into three parts. At each side it is filled with the lungs (right and left). In the middle portion there are the heart and great blood vessels, the trachea and its branches, the oesophagus, the thoracic duct, and lymphatic glands.

Surrounding each lung is a double bag called the **pleura**, the inner layer of which is attached to the lung itself, while the outer layer is fastened to the chest wall. In health these two layers are in close contact and can move smoothly over each other, the surfaces being lubricated by a small quantity of fluid. In the disease known as pleurisy these smooth surfaces become roughened, and pain is felt every time one surface rubs against the other.

The heart is contained in a similar double bag called the **pericardium**. The inner layer of pericardium covers the heart closely, and the outer layer forms a loose bag in which the heart moves. A small amount of fluid lubricates the two surfaces.

20. The Abdomen and its Contents

The abdomen is bounded *in front* by the abdominal muscles, passing from the ribs to the pelvis; *at the sides* by the same muscles; *behind* by the lumbar vertebrae, sacrum, coccyx, and muscles of the back; *above* by the diaphragm; *below* by the pelvic bones and muscles.

It is lined by a thin glistening membrane—the **peritoneum**—which also covers all the organs contained in the abdomen. This smooth membrane is kept continually moist by a small amount of fluid which it secretes. In the abdomen are the stomach and intestines, the liver and pancreas, the spleen, the kidneys, ureters, and bladder. Immediately under the diaphragm and chiefly on the right is the liver, a large organ with a curved upper surface to fit the arch of the diaphragm. On the left, touching the diaphragm, is the stomach, the right end of which is continuous with the duodenum, or the first part of the small intestine or gut. The duodenum forms a noticeable bend which brings it under the stomach. The remainder of the small intestine forms a number of coils situated in the middle of the abdomen, making a total length of about 20 feet.

At the lower right hand corner of the abdomen, the small intestine enters the large intestine. This is much broader

than the small intestine, and is about six feet in length. It passes up the abdomen on the right, across to the left just below the stomach, and down on the left side. The last nine inches form the rectum; this ends at the anus.

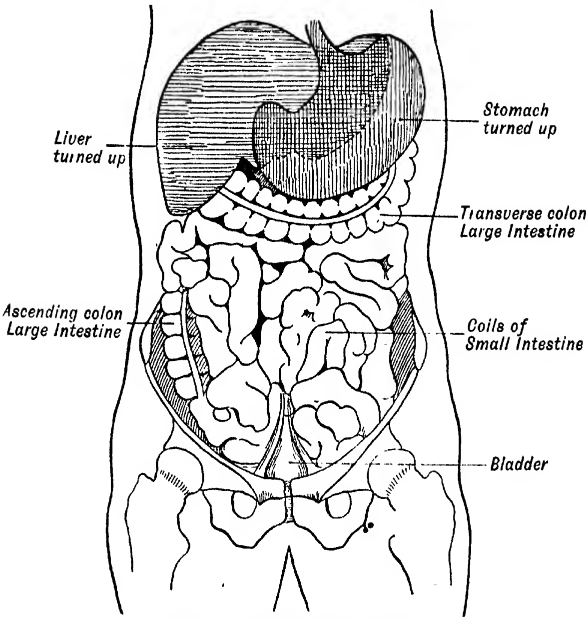

Fig. 15. Contents of Abdomen.

On the left of the stomach is a small dark-coloured body, the spleen. In the bend of the duodenum, below the stomach, is a soft irregular body, the sweetbread. The kidneys are fixed to the posterior wall of the abdomen, and two ureters, or tubes, convey the urine from them to the bladder.

PRACTICAL WORK

The following examination of the three types of simple levers will be instructive.

(*a*) FIRST KIND.—Place a hooked stick over the back of a chair, so that one-third of its length (the hooked end) projects one way and two-thirds the other way. The part of the stick resting on the chair remains fixed and forms the fulcrum. Place a bag containing a weight (say 6 lb.) on the hook. Place the hook of a spring balance round the end of the stick and hold the stick horizontally by this means. The spring balance will register a pull of 3 lb. This shows that by means of the lever, arranged as above, a weight of 6 lb. at one end is balanced by a pull equal to 3 lb. at the other end of the lever (*i.e.* the end twice as far from the fulcrum).

On moving the fulcrum (the chair) nearer the weighted end the reading of the spring balance decreases, showing that large weights can be lifted by means of levers with a small expenditure of effort. Note the indications of the spring balance for various positions of the fulcrum.

(*b*) SECOND KIND.—Place the end of the stick on a table. This end remains fixed and forms the fulcrum. Then hang the weight from the middle, and support the free end by means of the hook of the spring balance held in the hand. The balance registers a pull of 3 lb. Alter the position of the weight and note the reading of the balance for various positions.

(*c*) THIRD KIND.—Fix one end of the stick, *e.g.* by insertion into a keyhole of a door. Hang the weight on the other end, and support it by means of the hook of the balance applied to the middle of the stick. Note the reading of the balance for this and other positions.

CHAPTER II

THE BLOOD. THE HEART

1. Plasma and Corpuscles in the Blood

To the naked eye the blood appears to be a red liquid, but under the microscope we see that it really consists of a clear colourless fluid in which are suspended a great number of small solid bodies. Most of these small bodies are red, and they give the red colour to the blood. The clear liquid part of the blood is called the **plasma**, and the small solid bodies floating about in it are called the **corpuscles.**

There are two kinds of corpuscles, *red* and *white*, the proportion being about 500 red corpuscles to 1 white corpuscle.

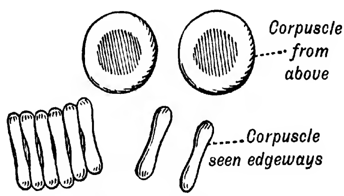

Fig. 16. Red Corpuscles (Magnified 1600 times).

2. Red Corpuscles

These are usually described as minute bi-concave discs. This means that they are round and flat like a penny, but are thinner in the middle than at the edge. The diameter of the disc is $\frac{1}{3200}$th of an inch, and it is about a quarter of that in thickness. When viewed under the microscope, they are seen to have a tendency to run together in rows like a pile of pennies. Their colour is not a bright red like the colour of blood, but much paler and yellower. A red corpuscle is made of a soft elastic and spongy material which contains in its meshes a red colouring matter called **haemoglobin.** The elasticity of the framework of the red corpuscle enables it to pass through the tiniest blood vessels.

Haemoglobin is a chemical substance capable of combining loosely with oxygen and forming **oxyhaemoglobin,** which has a bright scarlet colour. This can easily give up its oxygen to various substances which it meets during its journey through the body. These substances are then said to be oxidised by the oxygen from oxyhaemoglobin. The haemoglobin therefore acts as the oxygen carrier of the body. In the lungs it absorbs oxygen and becomes oxyhaemoglobin, and then this oxygen is carried all over the body to burn up or oxidise the waste products of the various parts.

3. White Corpuscles

These vary very greatly in form and in size. They average $\frac{1}{2500}$th of an inch in diameter. The red corpuscles have no power of movement of themselves, but the white ones are constantly moving and changing their shape. Each white corpuscle is a complete cell, made of a clear jelly-like substance called **protoplasm,** and, if the cell is treated in a certain way, a rounded body can be distinguished which appears darker than the rest of the cell. This body is called the **nucleus.** Human red corpuscles have no nucleus.

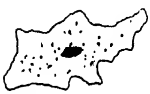

Fig. 17. White Corpuscles (Magnified 1600 times).

4. Clotting of Blood

A few minutes after its withdrawal from the body the blood sets to a kind of jelly. In fact it looks very much like red jelly. About an hour afterwards a few drops of pale yellow liquid appear on the top of the clot, and the surface of the clot becomes concave. The clot is shrinking and is squeezing out the pale yellow liquid—the **serum.** The clot continues to contract, and more serum appears until finally there is a red clot floating in serum. If examined under the microscope this serum will be found to contain no red or white corpuscles.

Serum is a yellowish liquid consisting of water, salts, and two complex nitrogenous bodies called albumin and globulin.

5. Uses of the Blood

Briefly these may be summarised as follows:—

(1) The haemoglobin in the red corpuscles acts as the oxygen carrier from the lungs to all parts of the body.

(2) The impurities of the body are carried by the blood to the lungs, kidneys, and skin, where they can be expelled.

(3) When the food is digested it passes into the blood, which conveys the nourishment to the various parts of the body.

(4) The flow of the blood through all parts keeps the temperature of the body uniform.

(5) The blood also contains substances which give immunity or protection against certain diseases.

(6) The white corpuscles are active defenders of the body, and they are capable of absorbing and destroying disease germs which may invade the body.

6. The Heart: Auricles and Ventricles

The **heart** lies in the thorax between the two lungs, and is partly covered by the lungs, but part of it is in contact with the chest wall. The walls of the heart are made chiefly of muscle, and the heart weighs nine or ten ounces. It hangs freely in a closed membranous sac called the pericardium. The inner surface of the membrane is smooth and shiny, as is also the outer surface of the heart. The constant movements of the heart can therefore take place in its bag without any friction. The heart is conical in shape, the base being uppermost and directed upwards and to the right, while the apex points downwards and to the left.

The heart is divided into a right and a left half by a partition, and there is no communication through this partition from one half to the other. Each half is again subdivided into an upper and a lower compartment called respectively **auricle** and **ventricle.** Each auricle communicates with the ventricle

of the same side by an opening which is guarded by valves. The object of these valves is to prevent any blood flowing from the ventricle to the auricle. They allow blood to flow freely from the auricle to the ventricle. In describing the heart it is best to consider separately its four cavities, the right and left auricles and the right and left ventricles.

The **right auricle** is a thin walled cavity. Opening into it are two large veins, the **superior vena cava** and the **inferior**

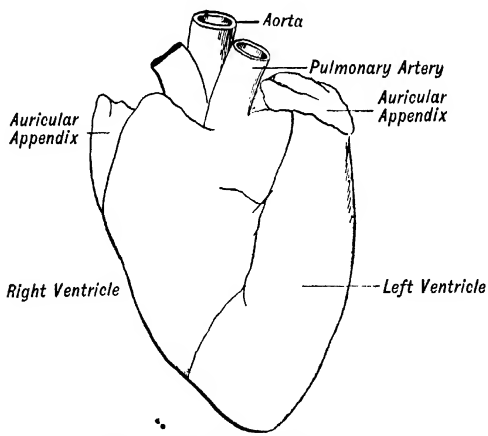

Fig. 18. SHEEP'S HEART (Front view).

vena cava. These veins bring blood from the whole of the body except the lungs.

The **right ventricle** is separated from the right auricle by a valve which is composed of three triangular flaps or cusps, and is called the **tricuspid valve.** This ventricle has much thicker walls than the auricle.

Leading from the right ventricle is a large blood-vessel called the **pulmonary artery,** because it carries blood to the

lungs. The opening from the right ventricle into the pulmonary artery is guarded by a valve to prevent blood flowing back into the ventricle after it has been forced into the artery.

The **left auricle** has thin walls. Opening into it are four **pulmonary veins** which bring blood from the lungs. Below, it communicates with the left ventricle by the **mitral valve.** This valve prevents blood passing from ventricle to auricle, but allows it to pass the other way.

The **left ventricle** is the thickest-walled cavity of the heart. It is longer and narrower than the right ventricle. The largest artery in the body—the **aorta**—proceeds from the left ventricle. The opening into the aorta is protected by valves which allow the blood to pass only from the heart into the aorta.

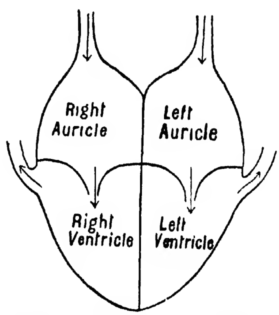

Fig. 19. Diagrammatic Heart.

7. The Beat of the Heart

A beat of the heart consists of a contraction of the walls of both auricles followed by a contraction of the walls of both ventricles. This takes place about 75 times in a minute on an average. In a new-born baby the heart beats one hundred and sixty times a minute, while in old people it only beats sixty times a minute or even less. Exercise increases the rapidity of the heart beat, which is generally quicker in women than in men. In nervous people the heart may become easily excited, and the beats increased in frequency. When this is exaggerated it produces a feeling called palpitation. Physical exercise accelerates the beat of the heart. Sudden violent exercise may severely tax the heart, which may prove to be unable to withstand the strain.

8. The Blood-Vessels: Arteries, Veins, and Capillaries

The **blood-vessels** are branched tubes which convey the blood to and from the different parts of the body. There are three kinds—**arteries, veins,** and **capillaries.** An artery is a vessel that brings blood from the heart to any part of the body, and the vessel carrying the blood back again to the heart is called a vein. When an artery reaches the organ which it supplies it breaks up into smaller branches, and then each branch subdivides again and again until very small vessels are arrived at. These are called capillaries because they are as

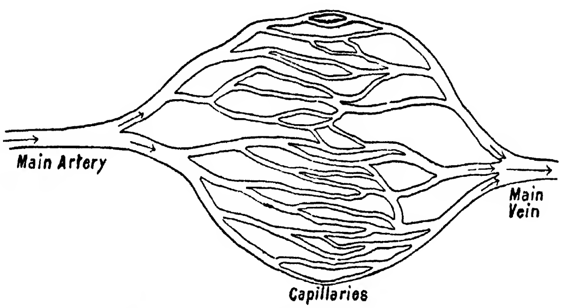

Fig. 20. Diagrammatic Representation of Artery, Capillaries and Vein.

fine as hairs. The capillaries eventually reunite and form the vein which takes the blood back to the heart.

The Arteries.—These are thick-walled vessels which do not collapse when empty. Their walls are strong and elastic, and consist of three layers—an inner, middle, and outer coat. The inner coat of an artery is a transparent colourless membrane. The middle coat is made up of layers of muscle and elastic tissue. In the large arteries this coat is chiefly elastic, and in the smaller ones it is mainly muscular. The outer coat is made of connective tissue.

When an artery has an extra quantity of blood suddenly forced into it, its elastic coat enables it to dilate, and afterwards to recover its normal size by contraction of its elastic walls. By means of its muscular coat the size of an artery can be regulated independently of the pressure of blood within it.

THE CAPILLARIES.—As the arteries get smaller they gradually lose their elastic tissue. Then the muscular coat diminishes and finally disappears, and we now have the capillaries: thus a capillary blood-vessel is simply a tube consisting of thin flat cells united together at their edges.

THE VEINS.—The capillaries gradually unite together and form large tubes, assuming the same three layers as in the arteries: thus the veins are formed. These three coats of the veins are, however, much thinner than the coats of the arteries and contain much less elastic and muscular tissue. A vein collapses when it is empty. Another difference between an artery and a vein is that many veins, especially those in the arms and legs, have valves which allow the blood to flow only towards the heart.

9. Circulation of the Blood

The blood is propelled along the arteries, capillaries, and veins by the unceasing contractions of the heart, which is a kind of muscular force-pump.

In any description of this circulation, it is best to begin with the blood that is contained in any one of the four chambers of the heart and to trace its journey through the body until it again reaches the chamber from which it started. We will begin with the blood in the right auricle.

When the right auricle contracts it forces the blood through the tricuspid valve into the right ventricle. Then the right ventricle contracts, closes the tricuspid valve by the pressure of blood, and forces the blood into the pulmonary artery. It passes along this artery and reaches the capillaries of the lungs, where it receives oxygen from the air in the lungs and

gives up some of its impurities to the air. The pulmonary veins bring the blood back from the lungs to the left auricle, which, by its contraction, forces the blood into the left ventricle through the mitral valve.

By the contraction of the left ventricle the mitral valve is closed and the blood is forced through and along the great artery of the body, called the aorta. This artery distributes

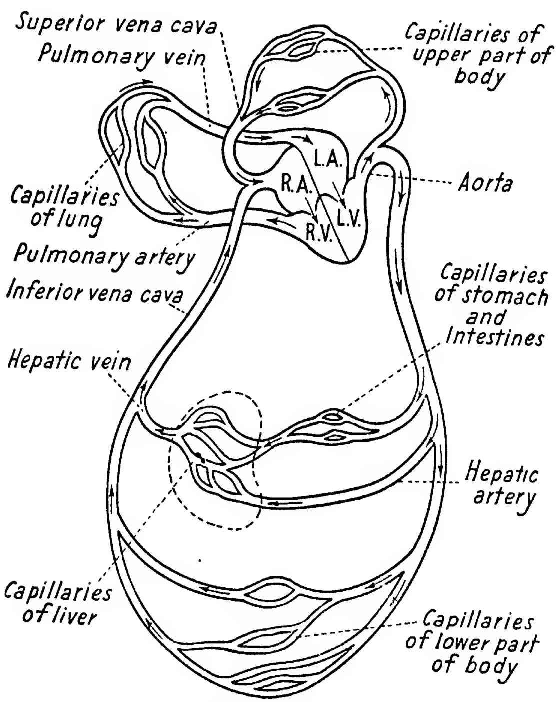

Fig. 21. Diagrammatic Plan of Circulation.

the blood over the whole body except the lungs. From the upper part of the body and upper limbs the blood is collected by veins which unite together and form a great vein—the superior vena cava. From the lower part of the body the blood is collected by veins which coalesce and form another great vein—the inferior vena cava. Both these great veins empty themselves into the right auricle. This completes the journey round the body, and the process is repeated continuously during life.

10. The Cause of the Circulation

The arteries have a definite quantity of blood forced into them at each beat of the heart. They will obviously therefore become overfilled with blood. Their elastic coat enables them to distend in order to accommodate much more blood than would fill them in their ordinary condition. The elasticity of the walls tries always to decrease the diameter of the distended arteries, and so there is set up a pressure in the blood—**blood pressure**—that tends to force the blood out of the arteries, *i.e.* into the capillaries. When the contents of the ventricles are suddenly pushed into the arteries an extra distension takes place in order to accommodate this extra amount of blood, and therefore the blood pressure will suddenly increase in the arteries at each contraction of the ventricles. This causes the pulsation of the arteries, *i.e.* the **pulse**.

The blood-pressure decreases in passing from the larger to the smaller arteries, because of the friction which opposes the flow in the small arteries and the capillaries. When the blood has reached the veins the blood-pressure is very small indeed.

PRACTICAL WORK

I. The Blood.—(*a*) Tie a string tightly round the last joint of the forefinger. The end of the finger becomes congested with blood. Hold a clean sharp needle for a second in a flame, and when cool prick the finger sharply just behind the

finger nail. A drop of blood collects. Just touch the blood with the middle of a clean microscope slide, and quickly cover the blood on the slide with a cover slip. Examine the film thus produced under the microscope, and note the red and white corpuscles and the almost colourless plasma. Remove the string from the finger.

(*b*) From a butcher obtain a jar filled with fresh blood. It quickly sets to a jelly or clot and the subsequent events should be observed and noted. Note the characters of the serum.

II. THE CIRCULATION.—(*a*) Stroke one arm downwards from the elbow. Notice the little swellings that stand out in the course of the veins. These show the situation of the valves which close up when the blood is forced in the wrong direction.

(*b*) Note the "pulse" by pressing the first two fingers of the right hand on the lower end of the left radius. Count the number of beats per minute. Count again after active exercise.

CHAPTER III

AIR. RESPIRATION

1. Atmospheric Pressure

The relative importance of air to the body is easily understood when we consider that there are cases on record of human beings living for five or six weeks without food, whereas deprivation of air causes death in four or five minutes.

It may easily be proved that the air has weight. This being the case it at once follows that it must exert a pressure upon us, as we live at the bottom of a sea of air many miles deep.

The actual pressure of the atmosphere varies slightly, but it is usually about 15 lb. per square inch, or about 14 or 15 tons on the body of the average adult. The pressure is equal in all directions and evenly distributed, the air in the lungs pressing outwards with almost the same force as the outside air is pressing inwards, and so, under ordinary circumstances, we are not aware of its existence.

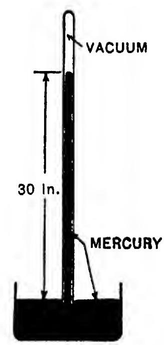

Fig. 22. Barometer.

The atmospheric pressure is measured by the *barometer*. This is a tube about a yard long and closed at one end. It is first filled with mercury, and then the thumb being placed over the open end, the tube is inverted in a vessel containing mercury. The mercury in the tube does not sink to the level of the mercury in the vessel, but remains about 30 in. higher, being kept up by the pressure of the air on the surface of the mercury in the vessel. The pressure of

the air will obviously be less on the top of a hill than at a lower level, and so the level of the mercury in the barometer gets lower the higher we climb. Also, cold air is heavier than warm air, and dry air is heavier than moist air. The barometer will therefore stand higher on a cold, dry day than when it is moist and warm.

2. The Composition of the Air

Ordinary air has a slightly variable composition. The average composition of dry air may be taken as:—

Nitrogen	78·06
Oxygen	20·96
Argon	0·95
Carbon dioxide	·03
	100·00

There are also variable quantities of water vapour, ozone, ammonia, acid gases, excess of carbon dioxide, and suspended impurities.

3. Oxygen

This is the most important constituent of the air. It is a clear, colourless gas without any taste or smell, and its presence is essential for all combustion and respiration.

Any substance that will burn in air burns with increased brilliance when dipped into a jar filled with oxygen. When a candle is lighted and placed in a limited volume of air, it can only burn as long as there is oxygen around it. But when a candle (or any combustible substance) burns in air it gradually uses up or combines with the oxygen, and so the amount of oxygen in the air round the candle will get less and less, until at last there is too little oxygen present to support the combustion of the candle, and the candle goes out.

In exactly the same way an animal uses up the oxygen and, unless fresh air is supplied, will die.

4. Nitrogen and Argon

Nitrogen is a clear colourless gas without any taste or smell. It is not at all active, being incapable of supporting combustion or respiration, and it is incombustible. It modifies the activity of the oxygen in the air.

Argon is a gas, as far as we know, of no hygienic importance, as it behaves in the same way as nitrogen.

5. Carbon Dioxide or Carbonic Acid Gas

Carbon dioxide exists in pure air to the extent of 3 parts in 10,000 of air. This means that 10,000 pints of air contain 3 pints of carbon dioxide evenly diffused through the whole bulk. It is a clear colourless gas with a faint pleasant taste and smell. It is very heavy for a gas, being about one and a half times as heavy as air. The property by means of which this gas is recognised is its action on lime water, which it turns milky. Carbon dioxide will not burn and will not support combustion or respiration.

Carbon dioxide is poured into the air in enormous quantities, being produced by the following processes:—

(1) By all ordinary cases of combustion, *i.e.* by the burning of coal gas, petrol, fires, etc.

(2) By the breathing of animals. All animals absorb oxygen from the air and give out carbon dioxide in their breath. Plants behave in the same way during both day and night.

(3) Carbon dioxide is produced during the numerous cases of fermentation and decay that are continually going on.

As the supply is so abundant it would seem reasonable to expect that the amount of carbon dioxide in the air would rapidly increase. It is found, however, that the amount in pure air remains stationary. This is owing to the action of

the plants upon the carbon dioxide. When the sun is shining, their green parts are capable of absorbing carbon dioxide from the air. They keep the carbon for growing purposes, *i.e.* to make wood, and give back oxygen to the air. Obviously, therefore, the chief effect of plants upon air is exactly the opposite to that of animals, and tends to decrease the amount of carbon dioxide in the air. As a matter of fact, plants are also continually taking in small amounts of oxygen and giving out carbon dioxide, just like animals, *but during the day this action is masked by the opposite one.* During the night, however, plants act in a very small way like animals and give off carbon dioxide, but such a result is negligible.

In large towns and in inhabited rooms the amount of carbon dioxide is often above 4 parts in 10,000 of the air. Workers in some conditions, as in breweries, are exposed to much larger proportions of carbon dioxide without injury, but in such cases the increase in the amount of carbon dioxide has not been brought about by respiratory contamination. Much importance has been attached to the presence of carbon dioxide in air, but recent experiments have demonstrated that *it is to the heating and stagnation of the air and to its saturation with water vapour* rather than to this gas that the impure air of overcrowded rooms owes its immediately harmful effects. It has been found that with as much as 170 parts of carbon dioxide in 10,000 of air no immediately injurious effects result so long as the temperature remains low and there is no excess of moisture present. Under these conditions as much as 300 parts of carbon dioxide in 10,000 of air can be tolerated by human beings for a period if the air is kept in rapid movement by electric fans. These experiments, however, have dealt with short periods only and do not necessarily prove anything about the conditions which are essential for a healthy existence.

Knowledge of the above fact can be put to practical use. In a crowded factory the arrangements for ventilation may be unsatisfactory and as a consequence the workpeople may feel the air "stuffy," and complain of sleepiness, fatigue, and

headache. At the same time the output of work is diminished with loss to both employer and workman. The provision of electrically rotated fans with a churning effect on the air will effect a great improvement by removing the sensation of "stuffiness." The workpeople will feel refreshed and there may be an increase in the output of work. Such devices, however, serve only as a makeshift for temporary purposes, and should not be adopted as a permanent substitute for efficient ventilation which can only be secured by constant renewal of air by admitting fresh air. The presence of carbon dioxide in excess of 6 parts per 10,000 must be regarded as indicating defective ventilation, and prolonged occupation of rooms in such conditions is undesirable.

6. Ozone

This is a chemically altered form of oxygen, found in small quantities in the air of country places and at the seaside, but absent from town air. It is artificially generated and mixed with the air supplied to some underground railways, where its presence is occasionally obvious to the sense of smell. The addition of ozone in this way is of doubtful benefit.

7. Water Vapour

Water vapour is always present in the air in varying quantity. It is produced (1) by evaporation from the surface of water; (2) by the respiration of man and of animals; (3) by combustion, *e.g.* of coal gas, coal, etc.

The warmer the air the greater the amount of water vapour that it can take up. When the air at any given temperature contains as much water vapour as it can hold it is said to be **saturated**, and when it is capable of holding more it is **unsaturated**. Obviously, if the temperature of a certain quantity of saturated air is raised it ceases to be saturated and becomes unsaturated, because it is now capable of taking up more water vapour. On the other hand, if the temperature of a given volume of saturated air is lowered it becomes

incapable of holding so much water, and so some of it appears in the form of rain, mist, or dew.

When the air is close to its saturation point it is said to be moist, and when it is far from saturated it is called dry air. The atmosphere contains about 1·4 per cent. of water vapour as an average.

8. Suspended Impurities

The presence of these impurities in air is shown when a ray of sunshine enters a darkened room. The tiny solid particles are of the most varied composition, some of the commonest being sea salt, sand, coal dust, minute seeds of plants, particles of wood, straw, cotton, etc., also scales of skin, hair, and innumerable microbes, most of them harmless. Suspended impurities are also produced by various trades. These irritate the lungs, and often set up disease. For this reason lung troubles are especially common among tin miners, needlemakers, cutlers, cement workers, etc. In white-lead works the dust gives rise to lead poisoning.

SMOKE.—This is the product of the combustion of soft coal usually in a domestic grate or in a badly stoked factory furnace. It is a constant source of pollution of the air of English towns and has many bad effects:—

(1) It increases the number and intensity of fogs with consequent loss from traffic delays and increased death from respiratory diseases.

(2) It cuts off the beneficial ultra-violet rays of the sunlight and so indirectly affects the health of town-dwellers.

(3) By darkening the sky it leads to unnecessary use of artificial light, which is wasteful.

(4) It leads to unnecessary soiling of body-linen and blackening of paint-work and decorations.

(5) It leads to windows being kept closed "to keep out the smuts."

(6) It exerts a slow destructive action on the fabric of buildings.

9. Special Local Gaseous Impurities

Carbon Monoxide.—This gas is given off from imperfectly burning charcoal stoves, and in other cases of partial combustion. For this reason such stoves should never be used without proper flues. Carbon monoxide is extremely poisonous, and fatal consequences have followed when the air contained only ½ per cent. of the gas. The symptoms are dizziness and headache followed by insensibility. "Water gas," which is now extensively added to coal gas, is very rich in carbon monoxide, and so such an addition makes coal gas very poisonous. An escape of coal gas into a room is a common cause of death by carbon monoxide poisoning. This poisonous gas is produced in many industrial processes, and is present in the exhaust gases from the engine of a motor car.

Coal Gas.—Coal gas is a mixture of gases obtained by the heating of coal in the absence of air. It should never be present in the air, as it is very dangerous for two reasons:—

(1) When mixed with air it may be explosive and may explode violently when a light is applied. Coal gas not mixed with air is not explosive in any way.

(2) It contains poisonous gases, especially carbon monoxide. Even in very small quantities it produces headache and sore throat. In larger quantities it produces a sense of suffocation, which is, however, rapidly followed by insensibility, so that the inhalation of the gas is a common way of committing suicide.

The commonest cause of an escape of coal gas is neglect to turn off the gas completely. Sometimes it may get turned on by accident, while other causes are leaky pipes and the evaporation of the water from old-fashioned chandeliers, or coal gas may enter a house from an escape into the soil

below. When an escape of coal gas is noticed, it is, of course, the height of folly to light a candle or match, and yet nearly all the fatal explosions have been caused by people going with a light to find where the gas is escaping. The proper course under these circumstances is to—

(1) Put out all naked lights (gas flames, candles, lamps) in the house. (2) Try to turn off the gas at the meter. (3) Open the windows to get rid of the poisonous and explosive gas.

The products of the combustion of coal gas are chiefly carbon dioxide and water vapour. One cubic foot of coal gas when burned produces about one cubic foot of carbon dioxide and one cubic foot of water vapour, and removes from the air about two cubic feet of oxygen. Now the average gas burner consumes about 4 cubic feet of gas per hour and, therefore, will produce 4 cubic feet of carbon dioxide, which is more than six times the amount that an ordinary adult would give off in his breath in the same time. Acid compounds of sulphur are also produced in small quantities when coal gas is burned. For this reason plants do not flourish as a rule in rooms lighted by coal gas. The paint of pictures and woodwork and other materials is also discoloured, and gradually damaged.

Drain Air.—Drain air occasionally finds its way into a house owing to the water in a water-closet drying up, or by escaping from a cracked or broken drain under a house. It is said to cause sore throat and such a condition of depressed vitality as renders one susceptible to infectious disease. It is, however, very difficult in practice to trace any connection between the existence of infectious disease and bad drainage. There was undoubtedly a close connection between bad drainage and typhoid fever, but the latter disease is now very uncommon in England. Workmen engaged in the sewers are not noted as suffering in health. In a sound well-ventilated drain the air should not be appreciably different from ordinary air.

VAPOURS FROM INJURIOUS TRADES.—The most important is the impurity arising from phosphorus in match-making. The fumes of the phosphorus give rise to a serious disease of the jaw (phossy jaw). In artificial-flower-making injurious effects are often produced by the arsenical vapours. Workers in copper and brass foundries are often affected by the fumes.

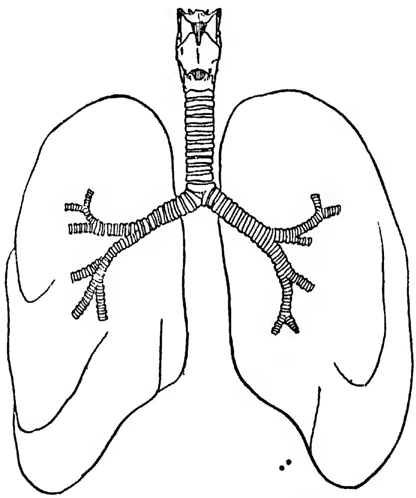

Fig. 23. TRACHEA AND BRONCHI.

10. The Respiratory System

On its way to the lungs the air passes through (1) the mouth or nose, (2) the pharynx—the cavity at the back of the mouth, (3) the larynx—the voice box, (4) the trachea—the windpipe, (5) the bronchi (windtubes) and their branches.

The **pharynx** is a wide funnel-shaped cavity, four inches long, at the back of the nose and mouth. It divides below

into two tubes, one behind the other. The posterior tube is usually collapsed, as it has only soft flabby walls: this is the gullet or **oesophagus,** the tube to convey the food from the pharynx to the stomach. The front tube has hard cartilaginous walls and so is always kept open: this is the beginning of the windpipe and is called the **larynx** or voice-box. It is continued below as the **trachea.** Within the larnyx are the vocal chords. The air passes through a narrow chink between them and can set them in motion like the reed in a whistle. This chink is the **glottis.**

The trachea is a round open tube, about 4½ inches long, and 1 inch wide. It is lined inside with cells, on the surface of which are numerous hair-like processes called **cilia.** These during life, are constantly in motion and tend to drive any fluid that is on them towards the mouth. In bronchitis the secretion in the tubes is abundant and the resulting phlegm collects at the back of the throat, whence it can be expelled by coughing.

Close to the lungs the trachea divides into two tubes called the **bronchi,** the right bronchus going to the right lung and the left bronchus to the left lung. These bronchi again divide and subdivide until finally the branches are so small that they can only be distinguished by the microscope. The small tubes are called **bronchial tubes.**

The lungs are made up of masses of the dilated ends of bronchial tubes. Each dilation is lined internally by a layer of flattened cells joined edge to edge. Beneath this is a layer of elastic tissue and a close network of capillary blood-vessels. The blood in the capillaries is only separated from the air by a very thin delicate partition. These capillaries are formed by the breaking up of the pulmonary artery into tiny branches, and these branches gradually unite to form larger tubes. These in turn unite to form the pulmonary vein which takes the blood back to the heart.

Externally the lungs are a mottled purple colour, are spongy and elastic to the touch, and are covered by a smooth glistening membrance, the **pleura.**

In the natural condition of the lungs in the thorax, the outer surface of each lung is pressed closely against the inner surface of the walls of the chest. The air has no access to the outside of the lungs, and the pressure of the atmosphere is warded off by the muscular and bony walls of the thorax. Inside the lungs, however, the air has free access through the trachea and bronchioles, and so the atmospheric pressure keeps the lungs distended, causing each lung to fill up completely each half of the thorax, like a blown-up elastic bladder.

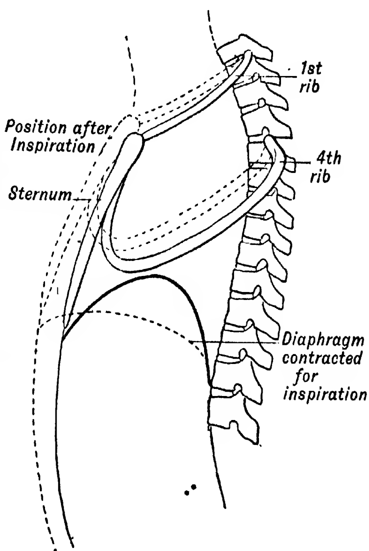

Fig. 24. Movement of Ribs, Sternum, and Diaphragm.

11. Mechanism of Breathing

When the cavity of the thorax is increased in size the pressure of the atmosphere expands the lungs by forcing more air into them. On the other hand, if the size of the thorax is decreased, some of the air is forced out by the pressure of the chest-wall, or the diaphragm, or both.

Respiration consists of two acts—(*a*) **inspiration** or drawing air into the lungs, and (*b*) **expiration** or the act of forcing air

out of the lungs. Respiration is effected by the alternate enlargement and contraction of the thorax, and the double act takes place in the ordinary adult about 16 to 20 times per minute.

Inspiration is effected chiefly by (*a*) the contraction and descent of the diaphragm, and (*b*) the contraction of the intercostal and other muscles, causing the ribs and sternum to be elevated. A reference to the diagram, Fig. 24, will explain the mechanism.

If the diaphragm contracts it will become straighter, and so enlarge the cavity of the thorax. This, as explained above, will cause air to rush into the lungs. The other method of increasing the size of the thorax is by elevating the ribs and pushing out the sternum. Each rib describes a greater arch than the one above, and evidently, therefore, if each is suddenly raised into the position previously occupied by the one above, the size of the thorax will be increased. In men the diaphragm is the more important factor in causing inspiration, while in women the movement of the ribs and sternum is more conspicuous.

Expiration is effected mainly by the natural elasticity of the lungs and the weight of the ribs. The elasticity of the lung tissue tends to force out the air, while the weight of the ribs causes them to fall, thereby reducing the size of the chest. In forced expiration, as in coughing or sneezing, the abdominal muscles are used in order to press up the diaphragm, thereby decreasing the capacity of the thorax and forcing out the air suddenly and violently.

12. Quantity of Air Involved in Respiration

At each inspiration an adult takes in about 30 cubic inches of air, and breathes out the same quantity during the succeeding expiration. This is called the **tidal air.** At the end of ordinary expiration an extra 100 cubic inches can be driven out by forced expiration. The air left in the lungs at the end of forced expiration measures another 100 cubic inches.

Obviously, therefore, at the end of ordinary expiration there are about 200 cubic inches of air in the lungs, and this air, which is called the **stationary air,** is only renewed by being mixed with the tidal air in the bronchial tubes. This mixing of the stationary air with the tidal air prevents too sudden changes of temperature in the lungs.

13. Changes in the Air due to Respiration

Respiration adds to the air the following:—(1) Water. (2) Carbon dioxide. (3) Organic matter, partly in the form of bacteria.

The quantity of carbon dioxide added is comparatively constant. In round numbers, 4 per cent. of oxygen is abstracted from the air in the lungs, whilst 4 per cent. of carbon dioxide is added to it.

Expired air therefore differs from inspired air in the following respects:—

(1) It contains more carbon dioxide.

(2) It also contains more water vapour.

(3) The oxygen is decreased.

(4) The temperature is raised to nearly blood-heat.

(5) It may contain traces of organic impurities.

14. Changes in the Blood

The blood that reaches the capillaries of the lung is impure, containing an excess of carbon dioxide and a deficiency of oxygen. It is purple in colour, and is derived from the veins of all parts of the body. When passing through the capillaries in the lungs the blood is only separated from the air in the lungs by a very thin membrane. Oxygen and carbon dioxide can pass readily through this membrane, and, as the result of this, blood going away from the lungs is "arterial" in character, has a bright red colour, and contains about twice as much oxygen as, but less carbon dioxide than, the blood coming to the lungs.

This extra oxygen is carried to the heart along the pulmonary vein, and from the heart all over the body by the arteries, and is used up in oxidising the waste matters of the body, thereby producing heat. Part of it returns to the lungs in the form of carbon dioxide and water, and is expired.

When at rest an adult breathes out ·6 cubic foot of carbon dioxide per hour. When at work this may rise to ·9 cubic foot for moderate work, or 1·9 cubic feet of carbon dioxide when doing hard work. The oxygen in this comes from the air, the carbon from the tissues of the body.

15. The Production of Droplets

In ordinary circumstances a slight quantity of mucus continuously passes upwards from the respiratory passages to the throat and mouth and is then swallowed together with the saliva. When the air-passages are at all congested and inflamed, as is the case when bronchitis is present, this mucus increases in amount and forms blobs of sputum or " phlegm." The person affected may swallow the sputum or spit it out. If he is at the same time affected by a cough, the act of coughing discharges particles of the sputum and saliva in the form of a spray or **droplets.** This can be readily demonstrated by holding a sheet of glass, or a mirror, in front of the mouth while coughing, and then examining the surface of the glass. A similar formation of droplets takes place in the act of sneezing and even in the act of talking to a small extent. These droplets may be discharged for considerable distances by coughing or sneezing. A child has about as much propulsive force in its cough as an adult. A person talking may propel droplets for two or three feet ordinarily, or up to 20 feet during loud speaking.

These droplets invariably contain microbes and if the sufferer has an infectious disease the droplets are an important means whereby infection can pass from such a person to another person. Influenza and measles are other examples of diseases which may be spread by droplet infection.

Persons suffering from any form of infection accompanied by catarrh, particularly the common cold, should be careful to shield the mouth with a handkerchief when coughing or sneezing, and not to talk in the face of another person.

In inhabited rooms the numbers of bacteria in the air often amount to 300 or 500 per litre of air. Their invariable presence in large numbers in occupied rooms represents the real and active danger that may arise from low standards of ventilation.

PRACTICAL WORK

I. The Atmosphere and Combustion.—The following are

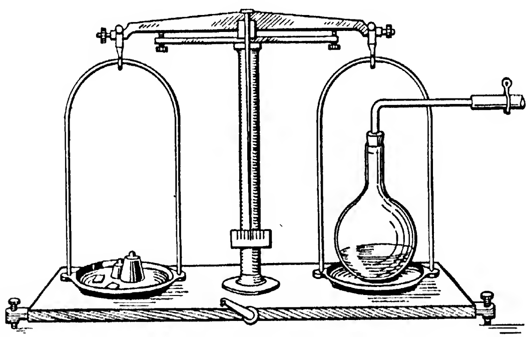

Fig. 25. Apparatus for Proving that Air has Weight.

some practical exercises dealing with the atmosphere and combustion.

(*a*) *The Weight of Air.* Take a round-bottomed glass flask fitted with a bung through which a short glass tube passes. At the end of the glass tube is fastened a short piece of india-rubber tubing. Place a small quantity of water in the flask, boil the water over a Bunsen burner, take away the burner, and quickly place a clip on the rubber tubing. Next place the flask on one pan of a balance and adjust weights on the other pan (Fig. 25) until on raising the beam, the flask

is "balanced"—in other words weigh the flask and its contents. The steam produced when the water was boiling has driven the air out of the flask and has taken its place. As the flask cools, however, this steam condenses and produces a partial vacuum in the flask. On opening the clip, therefore, the air rushes in. On weighing the flask, etc., again it will be found that the weight has increased.

(*b*) *The Pressure of Air.* The great pressure of the air is simply illustrated by the following experiments. A flimsy tin vessel is taken, and a small quantity of water poured into it. This is boiled for a few minutes over a Bunsen flame and then a cork is quickly inserted into the vessel. If cold water is now poured over the vessel it collapses owing to the pressure of the air on the outside. The atmospheric pressure is measured by the **barometer.** The student should make the simple barometer described on page 31.

(*c*) *Combustion of Candle.* Hold a cold, dry tumbler over a burning candle. Notice that a mist forms on the inside of the tumbler, and that after a short time this resolves itself into small drops of water which run down the sides of the glass.

(*d*) *Combustion of Coal Gas.* Hold a flask filled with cold water over a Bunsen flame. Note the mist formed on the glass and, subsequently, the formation of drops of water. Repeat with the flame of an oil lamp.

(*e*) *Combustion of Oil.* Hold a glass jar over a small oil lamp flame for a few moments. Close the jar by a plate and allow to cool. Pour into the jar a little lime-water and shake up after replacing the plate. The lime-water is turned milky, showing that carbon dioxide has been produced by the combustion of the oil.

(*f*) *Combustion.* Repeat the above experiment, using a small gas flame instead of the oil lamp. The same result is obtained, showing that carbon dioxide is also produced by the combustion of coal gas. Similar results may be obtained with a candle flame.

II. The Breath.—(*a*) To prove the presence of moisture, breathe upon a cold surface such as a piece of glass or slate.

(*b*) Carbon dioxide is detected by blowing down a glass tube into lime-water contained in a small beaker. Notice that the lime-water becomes turbid.

(*c*) Organic impurities are proved to be present by blowing through water made pink by a drop of Condy's fluid. In a short time the bright pink colour becomes duller, and finally changes to brown after standing.

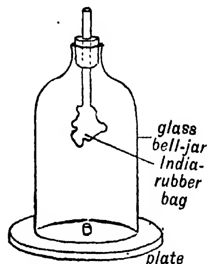

Fig. 26. APPARATUS FOR ILLUSTRATING MECHANISM OF RESPIRATION.

III. MECHANISM OF RESPIRATION.—The bell jar in Fig. 26 is placed on the plate of an air pump and the air is extracted. The tube at the top has attached to it the collapsed indiarubber bag which represents the lungs. When the air is extracted the effect is the same as is produced in the chest by depressing the diaphragm and raising the ribs, *i.e.* the pressure inside the bag (or lungs) becomes greater than the pressure outside, and the bag expands.

Another method of illustration is obtained by using the apparatus shown in Fig. 27, which is similar to that used in Fig. 26 except that the bottom of the jar is formed by a sheet

Fig. 27. APPARATUS FOR ILLUSTRATING THE MECHANISM OF RESPIRATION.

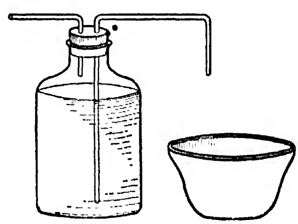

Fig. 28. APPARATUS TO MEASURE VOLUME OF AIR BREATHED.

of indiarubber, which represents the diaphragm. When the sheet is pulled downwards the capacity of the jar is increased and the rubber bag is expanded by the air rushing in through the tube at the top.

IV. Volume of Air Breathed.—(*a*) Measure your chest when it is expanded to its maximum extent. Then again when it is emptied of air as far as possible. The difference should be about 3 inches in an adult. If less it can be increased by careful breathing exercises, which will probably have an astonishing effect on the general health.

(*b*) Fit up the apparatus shown in Fig. 28. Fill up your chest with air to the maximum extent and then blow through the short tube as strongly and as long as you can. The amount of breath you blow into the jar is measured by the volume of water expelled from the jar. By pouring this water into a measure you will know its volume. This volume, representing the amount of air that can be breathed out after the deepest possible inspiration, is called the **vital capacity**. It is usually about 230 cubic inches.

CHAPTER IV

VENTILATION

1. Ventilation

This may be defined as the dilution or removal of the products of respiration, skin activity, and combustion by the supply of fresh air.

The depressing effects of the products of respiration are principally due to their raised temperature and the presence of excessive moisture. When confined in a small space, persons surrounded by and breathing the products of respiration have a difficulty in parting with their own bodily heat and their skins cannot work properly. This causes discomfort, drowsiness and mental and physical inactivity. Some injurious effect may also be due to organic matter present in expired air, especially microbes, which may thus actively spread disease. Carbon dioxide in itself is apparently harmless in the amounts found even in badly ventilated rooms. The diminution in the proportion of oxygen does not appear to be of any immediately serious importance. The proportion of carbon dioxide in the air in a room is a convenient indication of the kind of ventilation that is being maintained.

Dangerous contaminations of the air, such as microbes, are difficult to estimate, but the estimation of the proportion of carbon dioxide present is comparatively easy, and is conveniently used to indicate the amount of vitiation of the air of a room. A method of estimating directly the extent to which the heat and moisture of a vitiated room interfere with bodily comfort is by means of an instrument called the *Katathermometer*, the description of which is, however, beyond the scope of this book. Comfort is maintained by preventing excessive humidity or undue rise of temperature, and by keeping the air in continual gentle movement.

The active dangers to health are the microbes which abound in badly ventilated rooms, even when complete comfort may be maintained by keeping down the humidity and the temperature, and by keeping the air in motion. Living, sleeping, or working can only be carried on healthily when abundance of fresh air is supplied.

A rough and ready test of the respiratory purity of the air of a room is by an experiment which is both simple and delicate. If after breathing fresh air one can detect any odour of stuffiness on entering a room it is a sure indication that ventilation is defective. This method cannot be used by the inmates of the stuffy room, whose sense of smell is blunted for the time being. They only become aware of the stuffiness when it is considerable in amount, and by feeling oppressed, overheated, and uncomfortable.

2. Effects of Bad Ventilation

This has been referred to in Sect. 1: the main points may be briefly summarised as follows:—

(1) Occupation of a badly ventilated room for a short period produces drowsiness and headache, but these ill-effects soon wear off on regaining the fresh air.

(2) If this exposure to foul air is prolonged from day to day, *i.e.* if the individual lives in badly ventilated rooms, the general health becomes impaired, and the tendency to bronchitis and catarrh is increased. Consumption or tuberculosis of the lungs very often occurs under such circumstances, and infectious diseases, when once started, spread very rapidly from one person to another. A striking illustration of the relationship between foul air and consumption is shown by army experience in the past. The Foot Guards had been allowed 331 cubic feet of space per man in their barracks, and the death rate from consumption among them amounted to 13·8 per 1,000 men; while the Horse Guards, with a cubic space of 572 feet per man, showed a mortality

of only 7·3 per 1,000 men. On increasing the cubic space per man there was a very marked diminution of the mortality from all causes.

(3) In extreme cases, when the products of respiration are breathed in a concentrated condition, rapid poisoning results. This is well illustrated by the incident of the Black Hole of Calcutta, where 146 persons were imprisoned in a room about 18 feet square and with only two small windows. In the morning there were 123 dead, and of the 23 who were living, several afterwards died.

3. Agents Purifying the Air

These also may be briefly summarised thus:—

(1) The rain as it falls washes the air free from most of the suspended impurities, including microbes. It also removes much of the organic impurities that may be present, as well as any acid gases such as oxides of sulphur, oxides of nitrogen, etc.

(2) The wind tends to produce a uniformity of composition and aids the removal of the impurities by distributing them. Diffusion also produces a similar result. (See Sect. 6.)

(3) The plants, as we have already explained, remove the carbon dioxide from the air during the day.

(4) The oxygen in the air gradually oxidises and renders harmless the organic impurities.

As the result of all these purifying agents the composition of ordinary air remains practically constant.

4. Amount of Air Required per Head

It is generally agreed by hygienists that an average adult produces sufficient respiratory impurity to pollute 3,000 cubic feet of pure air in one hour. Therefore 3,000 cubic feet of fresh air must be supplied for each person in a room.

It is found that the air in a room can be changed three times per hour without causing any draught, and so, if 1,000 cubic feet of space are provided for each person, and we change the air three times per hour by proper ventilation, the necessary 3,000 cubic feet of fresh air are supplied.

For example, suppose it is desirable to know how many people may be allowed to sleep in a room 12 feet long, 8 feet broad, and 10 feet high: here the cubic contents are $12 \times 8 \times 10$, *i.e.* 960 cubic feet. Evidently from the above, only one person should sleep in such a room unless specially effective methods of ventilation are adopted so as to change the air more than three times per hour. In calculating the contents of a room more than 12 feet high it is best to reckon 12 feet only for the height, because cubic space is of no value when it is principally obtained by means of lofty ceilings.

For sick people the supply of fresh air should be at least half as much more than that allowed in health, *i.e.* 4,500 cubic feet per hour. Five hundred cubic feet of space for each person should be taken as the minimum permissible in any circumstances.

5. Natural and Artificial Ventilation

The methods of ventilation may be divided into two kinds —the natural and the artificial. By **natural ventilation** we mean any method that depends upon the natural forces which set air in motion, without the use of any mechanical means. It is produced merely by providing suitable openings. **Artificial ventilation**, on the other hand, depends upon the use of pumps, fans, bellows, etc., to set the air in motion.

Two properties of gases play a very important part in ventilation; these are (1) diffusion, and (2) changes in the density of air produced by heat.

6. Diffusion of Gases

Diffusion is the property of gases to mix thoroughly even against gravity, *i.e.* a heavy gas will diffuse upwards (as well

as downwards) and mix with a lighter gas, and a light gas will diffuse downwards (and upwards) and mix with a heavier one.

For instance, if in Fig. 29 the upper jar is filled with coal gas, which is a light gas, and the lower jar with air, which is a comparatively heavy one, then, on removing the plates between them and allowing them to diffuse for about half an hour, the lower jar will be found to contain just as much coal gas as the upper jar, and both may be lighted. The same result would be obtained, after a long time, if a partition of some porous substance, such as unglazed earthenware, were placed between the jars.

Another simple experiment illustrating the rapid diffusion of gases is to fill a jar with coal gas, close it with a cork or plate, and remove the plate after standing the jar on a table. In a short time the smell of coal gas can be perceived all over the room, showing that it has diffused to every part.

It is found that the lighter a gas is the faster it diffuses, and that if a light gas is on one side of a porous partition and a heavier gas on the other, then the light gas will diffuse through into the heavy one faster than the heavy gas will diffuse into the light one.

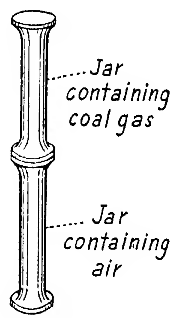

Fig. 29. Diffusion Experiment.

In an ordinary room the air is warmer and, as we shall see, lighter than the cold air outside. Diffusion outwards, therefore, will take place at a greater rate than diffusion inwards, and fresh air will enter the room not only as the result of this process of diffusion but also in order to equalise the pressure inside and outside the room. Diffusion through the walls of a room is greatly interfered with by the paper, plaster, and paint with which the walls are covered.

As an example of the power of diffusion as a ventilating force it is said that in the case of a cubical room with brick

walls, contents 3,000 cubic feet, and difference of temperature between the inside and outside air being 35° Fahr., the air would be completely changed in one hour by diffusion alone.

7. Changes in the Density of Air

When air is heated it expands. For this reason a pint of cold air will weigh more than a pint of hot air. Hot air, therefore, rises and cold air will take its place. This is exactly how **winds** are produced. The surface of part of the earth becomes heated by the sun; this warms the air in contact with it and causes it to expand and rise; the colder surrounding air then rushes in to take its place and a wind is produced.

The application of this to ventilation is easy. Foul air—being a product of respiration and combustion—is always warmer than the fresh air, and so it will rise, and if an opening is provided, it will escape. Fresh air will then enter through any opening to take its place. For the same reason the hot air over a fire goes up the chimney, and is replaced by fresh and colder air entering by windows, door, keyholes, and cracks.

Wind, as a ventilating agent, may act in two ways. (1) By perflation, *i.e.* by blowing through a room when the doors and windows are open. (2) By aspiration, which is illustrated, for example, by the draught up a chimney when there is no fire below: the wind blowing over the top of the chimney lessens the pressure of air in the chimney, producing an up-draught, while fresh air is drawn in the room to take its place.

In crowded courts surrounded by higher buildings this ventilating action of the wind is greatly interfered with.

8. Openings for Ventilation: Position of Inlets and Outlets

It is most important that an **outlet** for foul air and an **inlet** for **fresh** air should both be provided. The common practice is to provide only the outlet and to make no provision for the entrance of fresh air. This inevitably leads to bad ventilation.

In order to admit the necessary 3,000 cubic feet of fresh air per hour an opening of 24 square inches must be provided, assuming the air to enter the room at an average velocity of five feet per second. If the velocity is greater than this it will give the sensation of draught. An outlet of the same size is also necessary, making a total of 48 square inches of openings for each person in the room.

The foul air is usually much warmer than fresh air, and so it rises to the top of the room. Outlets, therefore, should be provided close to the ceiling. The best place for inlets is, theoretically, at the level of the floor, but in practice this is found to produce draughts, giving rise to cold feet and general discomfort. If the incoming air is warmed by passing it over hot pipes, it may be introduced at the floor level, but under ordinary circumstances it is best to arrange inlets at about six feet from the floor and to direct the current of air upwards.

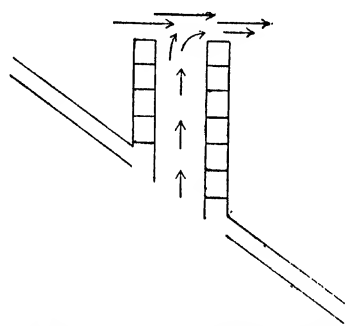

Fig. 30. Aspirating Effect of Wind Passing Over a Chimney.

9. Ventilators for Rooms

In an ordinary room the chimney is the chief ventilator, and should on no account be closed. It acts as an outlet. The only inlets, as a rule, are the windows, the door, and the numerous cracks in the frames and walls.

In criticising any form of inlet ventilator, attention should be devoted to the following points:—(1) The size of the opening should be adequate. (2) The size of the opening should

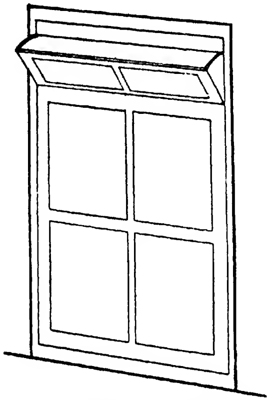

Fig. 31. Ventilation by Hinged Top of Window.

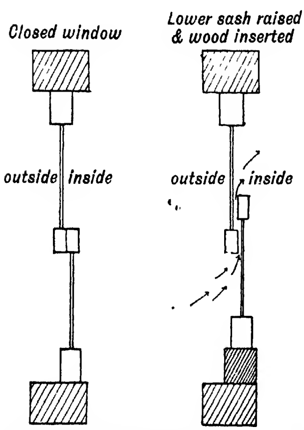

Fig. 32. Hinckes Bird's Method of Window Ventilation.

be capable of being altered. (3) The incoming air should be deflected upwards.

10. Window Ventilation

The various arrangements for window ventilation may be briefly summarised as follows:—

(1) The simplest and most obvious method of ventilation is that of open windows; and in warm weather it is undoubtedly the best. In cold weather, however, it is not popular as it is very liable to produce "draughts" which most people dread, and which often produce serious "chills."

(2) The upper part of the window can be made to work on a hinge so that the top moves into the room. Triangular pieces of glass or wood should be placed at the sides to prevent down draught. The current of fresh air will then be directed upwards, as is the case with all efficient ventilators.

(3) A very simple and excellent method of window ventilation is that suggested by **Hinckes Bird.** The lower sash is raised, and a block of wood is accurately fitted in the opening below so as to close it completely. Fresh air enters between the two sashes and is directed upwards.

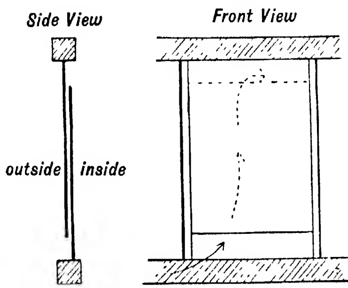

Fig. 33. Ventilation by Double Panes.

(4) The method of **double panes** has also been used. The inner pane leaves a space at the top and the outer pane leaves a space at the bottom, so that the fresh air enters between the two and is directed upwards. An objection to this method is that as these panes are generally fixed the space between them cannot easily be cleaned.

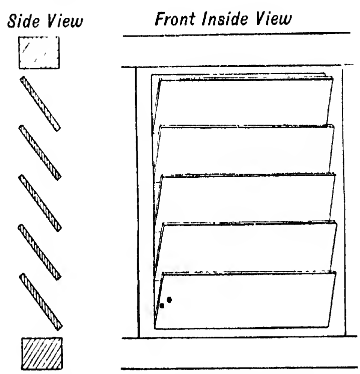

Fig. 34. The Louvre Ventilator.

(5) The **Louvre Ventilator** is also occasionally used. One or more of the ordinary panes of glass are removed and the space fitted with strips of glass arranged in exactly the same way as a Venetian blind. The amount of opening between

the strips can be adjusted by cords. The strips slant upwards from the outside, and direct the current of air upwards.

(6) Another device is the **Cooper's Ventilator.** A special pane is fitted in the window containing five holes arranged in a circle. Inside this is fixed a circular disc, working on a central pivot, and containing five exactly similar holes. The disc can be turned so that its openings correspond with those in the window pane, in which case air could pass through into the room, or so that its openings lie between those in the window pane, thereby closing the ventilator.

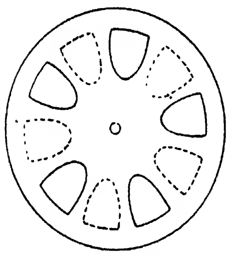

Fig. 35. Cooper's Ventilator.

11. Other Inlets and Outlets

The **Sherringham Valve** is an iron box fitted into a hole in the wall about seven feet above the floor. It has a grating on the outside and a hopper valve on the inside and acts as an inlet. **Ellison's Bricks** are bricks perforated with conical holes, the apex of the cone being towards the outside: they also act as inlets. **Arnott's Valve** is an outlet into the chimney: it is fitted with a valve which swings towards the chimney but not towards the room, so that foul air can pass from the room to the chimney but smoke cannot pass back into the room.

Other devices, among which may be mentioned **Boyle's Mica Flap, McKinnell's Ventilator,** etc., are occasionally used: these may be consulted in the makers' catalogues. But whilst the reader will still meet all the above devices in practice, their uncertainty of perfect action and "the cult of the open window" have caused them to lose favour in recent years.

All the above ventilators provide "natural" ventilation.

12. Artificial Ventilation

Natural methods of ventilation are found to be inadequate for cinemas, theatres, churches, concert halls, etc., where large numbers are collected for limited periods. In these cases the movements of the air must be controlled by machinery. This may be done in two ways: (1) By **aspiration,** or the extraction of the foul air from the rooms, the fresh air entering where it can; (2) By **propulsion,** or the pumping in of fresh air, leaving the foul air to escape as best it may. Of these two methods, propulsion is the better, because in this case the fresh air can be purified and warmed before it enters the rooms, whereas in the aspiration method there is no control over the incoming air, and it may possibly be drawn from some undesirable source.

Artificial ventilation is employed commonly for large buildings, and in most cases the purified and warmed air is pumped in, and the foul air escapes by shafts or flues.

Open windows and direct ventilation appear, however, more healthful for hospitals, schools and houses.

Permanently closed windows are essential for the proper working of most systems of artificial ventilation and are a bad object lesson to scholars at school.

PRACTICAL WORK

I. Diffusion.—Perform the experiments described on page 53.

II. Ventilation Openings.—(*a*) Arrange three candles on a stand as in Fig. 36. If no adjustable stand can be obtained use three lengths of candle, full length, half length, and one inch long. Light them and place over them a large stoppered jar without a bottom. Note behaviour of the candles (1) when the stopper is in and the jar rests on the table, (2) when the stopper is removed and there is a small space between the table and the jar. In the first case the top candle goes out first, and then the lower ones, while in the second case the candles will continue to burn brightly.

(*b*) Take a glass cylinder with open ends and place it over a lighted candle, so that the cylinder rests on the table. On the top place a piece of tin or cardboard with a circular hole in it, as in Fig. 37. The candle will die out. Repeat the experiment, but this time allow a small space between the table and the jar.

(*c*) Repeat the experiment (*b*), but when the candle flame is dying down insert a T-shaped piece of cardboard into the hole at the top so as to divide it equally into two parts. One half

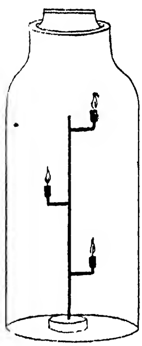

Fig. 36.

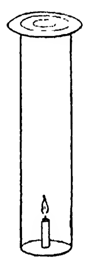

Fig. 37.

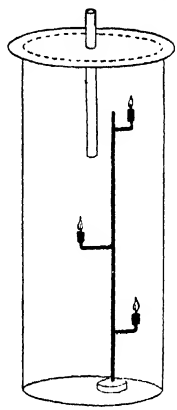

Fig. 38.

then acts as an inlet and the other as an outlet, and the candle continues to burn brightly.

(*d*) Arrange the candles as in Fig. 38, with a bottomless jar over them. A piece of cardboard rests on the top of the jar, and a glass tube passes through the centre of this, and reaches below the level of the upper candle. Light the candles and arrange the jar over them so that there is a small space between it and the table. Note the result and write down your explanation of it.

III. General.—By means of a lighted taper or candle test the direction of the air currents at a slightly open door communicating between a warm room and a passage or other room at a lower temperature, (*a*) holding the candle near the top of the door, and (*b*) near the floor. It will be seen that at the top of the door the flame is blown outwards showing that the hot air is escaping from the room, while at the floor level there is a stream of cold air entering to take its place, and this blows the flame inwards.

CHAPTER V

FOODS

1. Principal Constituents of Food

The materials used for food by mankind in various parts of the world show astonishing variability as regards appearance and taste, but all of them can be shown to consist essentially of some or all of the following:—

(1) PROTEINS.—These are foods containing nitrogen. They are found in all the meat foods, in fish, in cheese and milk, and in certain vegetables such as peas, beans and lentils.

(2) FATS.—These are found in milk, butter, cream, oils, margarines, and fatty parts of food generally.

(3) CARBOHYDRATES.—Starches or sugars, which are found in milk, rice, tapioca, sago, potatoes, and the like are known as carbohydrates. Bread is a starchy food, mainly, and it contains a small amount of protein and fat.

The mere presence or absence of sufficient of these three things, up till comparatively recently, was regarded as the only thing that mattered. It was subsequently found that the three principal constituents—proteins, fats, and carbohydrates should be present in the correct proportions the one to the other. If these proportions are not present then the diet is either insufficient or unbalanced and wasteful.

(4) MINERAL SUBSTANCES.—These, including lime (calcium), phosphorus, and other minerals in the form of inorganic salts, are really just as important parts of our food as proteins, fats and carbohydrates. Iron is found in small quantities in almost every tissue in the body, and it is an essential constituent of the blood. Salts of potash and soda, especially the chloride of sodium or common salt, are among the necessities of the body.

(5) WATER.—This is of supreme importance as an article of diet.

(6) VITAMINS.—Vitamins are also now regarded as essential. Modern research has shown that a diet of proteins, fats and carbohydrates, with a suitable admixture of mineral salts and water, is really not in itself sufficient to maintain health, although it may be correct as regards amount and proportions. It is also a fact that some conditions of ill-health are due to an absence or deficiency of other substances in the food, which are essential for proper nutrition. These substances are called *vitamins*. There are several vitamins known, these being called Vitamin A, B, C, D and E respectively:—

(*a*) *Vitamin A*. This vitamin is necessary for normal growth and development. Its absence from the diet causes lowered vitality and lessened ability to resist disease and infection. Vitamin A is present in animal oils and fats, but not in such as lard, which has been heated and exposed to air. It is absent from vegetable oils and fats. Cod-liver oil, liver, egg-yolk, green stuffs and milk are usually found to be rich sources of this vitamin, which is growth-promoting and anti-infective.

(*b*) *Vitamin B*. This is the substance which maintains the proper balance and nutrition of the nervous system. It is also necessary to ensure satisfactory growth and development in young children. Vitamin B is widely distributed in natural food-stuffs. It is present in all the seeds of plants, for instance, in peas and beans, in the wheat grain before it is milled, and in yeast. It is also present in cellular organs, such as liver, kidney, heart, fish-roe and eggs. Other articles of diet, such as meat, milk and nuts contain a small proportion.

(*c*) *Vitamin C*. This substance is necessary for the normal working of the body and a lack of it causes a disease known as scurvy. It is found in green stuffs, germinating seeds and

in fresh fruits and their juices. Infants fed on boiled milk are found to need a little fruit-juice to prevent them from getting scurvy. The most potent juices are those of oranges, lemons, tomatoes or swedes. Grapes, apples and bananas are a poor source of this vitamin, although of course valuable in other ways.

(*d*) *Vitamin D.* This substance is concerned in preventing young children from developing the disease known as rickets. It is present in egg-yolk and in cod-liver oil and is usually present in milk and butter. It is produced by the action of sunlight on plants, and by sunlight acting on the skin. It profoundly influences the development of bone and teeth.

(*e*) *Vitamin E.* This is very widely distributed and is the most stable of all the vitamins. It controls the function of reproduction and is contained specially in milk, green vegetables and wheat germ.

We will now proceed to consider proteins, carbohydrates, fats, etc., in some detail.

2. Proteins

Proteins or nitrogenous food-stuffs are composed of carbon, hydrogen, oxygen, nitrogen, sulphur and phosphorus. They are present in many foods, both of animal and vegetable origin. Thus there is **albumin** in white of egg, **myosin** in lean meat, **gluten** in flour, **fibrin** in blood, **casein** in milk and cheese, and **legumin** in peas and beans, while in the stomach and small intestines are substances called **peptones,** which are the products of the digestion of proteins. The first three —albumin, myosin and gluten—are coagulated by heat. The result of cooking any food containing either of these three principals will, therefore, be to coagulate the protein constituent.

The *use of proteins* is to build up the nitrogenous tissues of the body, and to repair these when worn out.

The average proportion of proteins present in some common foods is:—

Cheese	28 per cent.	Eggs	13 per cent.
Peas	22 ,,	Oatmeal	13 ,,
Beef	21 ,,	Bread	8 ,,
Fish	14 ,,	Milk	5 ,,

3. Fats

Fats are compounds made up of carbon, hydrogen and oxygen. Chemically they are compounds of fatty acids with glycerine. Thus **palmitin** is the fat composed of palmitic acid and glycerine, **olein** the compound of oleic acid, and **stearin** and **butyrin** the fats containing stearic and butyric acids respectively. *The ordinary fats in food contain varying proportions of stearin, palmitin and olein.* The greater the quantity of olein present the less solid is the fat. For this reason bacon fat is less solid than beef fat, and beef fat than mutton fat. Butter is a very digestible form of fat. One of the most digestible of all fats is cod-liver oil, which contains no stearin.

The *use of fats* is to produce heat and energy by the oxidation of the carbon and hydrogen into carbon dioxide and water. They also repair the fatty tissues, and their presence in the intestine stimulates the flow of bile and pancreatic juice, thereby aiding the digestion of the other foods. As a general rule, the harder the work to be done and the colder the surroundings, the more fat is required in the diet. Fatty foods also are valuable sources of vitamins. The following table gives some idea of the average proportion of fat present in common foods:—

Butter	85 per cent.	Eggs	12 per cent.
Bacon	73 ,,	Salmon	7 ,,
Goose	45 ,,	Oatmeal	6 ,,
Pork	34 ,,	Milk	4 ,,
Cream	27 ,,	Peas	2 ,,
Eel	24 ,,	Sole	½ ,,

4. Carbohydrates

Carbohydrates—a group which includes all starches, sugars and gums—are composed of carbon, hydrogen and oxygen. As a rule they are of vegetable origin.

The *use of carbohydrates* is similar to that of fats. They are producers of heat and energy, but they are probably inferior to fats in this respect. They also may be converted into fat in the body. It would seem at first sight, therefore, that the carbohydrates may be substituted for fats in a diet, but experience shows that a withdrawal of fat from a diet is not balanced by the addition of carbohydrates. For a good diet both fats and carbohydrates should be present. Being much cheaper than fats, the carbohydrates form very important foods for the poorer classes.

Starch consists of tiny granules which have slightly different appearances according to the sources, *e.g.* wheat, rice, sago. In its uncooked state a starch granule is very indigestible because it is enclosed in a covering of cellulose. When cooked, however, the cellulose coat bursts and the starch is set free.

The following table shows the percentage of starch in some common foods:—

Tapioca	nearly pure	Oatmeal	63 per cent.
Sago	starch.	Peas	59 ,,
Rice	79 per cent.	Wheat bread	47 ,,
Wheat flour	66 ,,	Potatoes	19 ,,

Common sugar is obtained from the sugar-cane, beet-root, or maple. Grape sugar is found in grape juice, and may be seen crystallised in dried raisins. Milk sugar is contained in milk.

5. Water

Water stands second only to oxygen among the necessities of life. About seventy per cent. of the body consists of water. It is not only essential to the body as a food, but it is also necessary because—

(1) It dissolves the foods when digested, and aids in their absorption.

(2) It maintains the fluidity of the blood, which contains about 80 per cent. of water.

(3) It assists in the removal of waste matters by the skin and by the kidneys.

The average person loses from 3½ to 5 pints of water per day from the skin, lungs, kidneys and intestines. This must be replaced in the food. Usually one-third of this amount is present in the solid food, leaving about 3 pints of water to be drunk per day.

In many foods the percentage of water is large, as shown in the following table:—

Green vegetables ...	... 90—95	per cent. water
Milk	.. 87	,, ,,
Fish	.. 75—80	,, ,,
Lean meat	... 70—75	,, ,,
Bread	... 35—40	,, ,,
Peas (dried) ...	... 13	,, ,,

6. Mineral Substances

These are present in every kind of natural food and are essential for the growth of the young and for the maintenance of good health. Some of the most important mineral substances may be mentioned.

Sodium Chloride, or common "salt," is present in all the fluids of the body. **Hydrochloric Acid** is derived from the common salt and is a constituent of the juices of the stomach. **Lime** is the source of the hardness and rigidity of the bony framework of the body. **Phosphorus** is present in all muscular and nervous tissues. **Iron** is a constituent of the haemoglobin of the blood. Small quantities of **iodine** in the food or drinking water are now known to be essential to health. In parts of Derbyshire and Switzerland the soil and water are lacking in iodine content, and swellings of the thyroid gland in the front

of the neck, or *goitres*, are common. It has been suggested that this condition might be prevented by a routine admixture of a small quantity of iodine salts with the table salt used, or by some other method of supplying the necessary iodine.

7. Accessory Foods

In the above classification of foods we have omitted to include many substances which enter largely into an ordinary diet, such as tea, coffee, cocoa, alcohol, as well as mustard, pepper, vinegar, etc. Experience has proved that many of these substances are useful as stimulants, or in exciting appetite and stimulating digestion.

Condiments is the general name given to substances which are added to food with the object of making it more tasty and palatable, thereby stimulating the digestive apparatus. This class includes mustard, pepper, salt, ginger, nutmeg, cloves, vinegar, etc.

We shall consider tea, coffee, cocoa and alcholic drinks in a later chapter under the head of " beverages."

PRACTICAL WORK

I. ALBUMIN.—(*a*) The white of egg is almost pure albumin plus water. Separate the white from the yolk, note the appearance and stickiness of the white, and test its effect upon a piece of litmus paper. The litmus is turned blue, showing that the albumin is alkaline.

(*b*) Put some of the white of egg into a test-tube and add about ten times its bulk of water. Shake up. The albumin dissolves.

(*c*) Place the solution of albumin in a small beaker and heat over a Bunsen flame, carefully noting the temperature of the liquid by means of a thermometer, which should be used to stir the liquid. No change is noticed until the thermometer stands nearly at 60°. Then the liquid becomes milky and the albumin coagulates or precipitates as a white solid. If the heating is continued the liquid boils but the albumin does not

dissolve, showing that the coagulated albumin is insoluble in water.

(*d*) Pour a small quantity of the cold solution of white of egg into a test-tube (about $\frac{1}{2}$ inch depth of liquid). Hold the tube slanting and pour down the side an equal quantity of strong nitric acid. The acid being heavier slips under the albumin solution and forms a separate layer, and where the liquids meet there is formed a white cloud of coagulated albumin.

II. PROTEINS.—(*a*) Place a fragment of cheese in a test-tube, add a little strong nitric acid, and boil. The cheese is stained a deep yellow. Pour away the nitric acid and add a little ammonia solution. The yellow colour deepens to orange. This is a good test for proteins either in solids or liquids. If a liquid is being tested the nitric acid cannot be poured away, and the addition of ammonia must be made with great care. It is best carried out by pouring the liquid from the test-tube into a beaker, and then adding the ammonia solution cautiously until the liquid, after mixing, turns red litmus paper blue.

(*b*) Test for proteins in the above way in the following foods: meat, bread, milk, white of egg, oatmeal, rice, peas.

III. STARCH.—(*a*) Mix a little starch with water, and add some iodine solution. The particles of starch are coloured dark blue. The production of a blue colour with iodine solution is a good test for the presence of starch.

(*b*) Make another mixture of starch and water so as to form a milky liquid. Filter carefully. A clear liquid passes through the filter, and if iodine solution is added to this it produces no blue colour, showing that the starch has not dissolved in cold water.

(*c*) Place some of the milky liquid as used in (*b*) in a test-tube and heat carefully over the Bunsen flame. As the solution gets hot it becomes much clearer. The starch has now dissolved. To a beaker nearly full of water add some of this starch solution and then add a few drops of iodine solution. A beautiful blue colour is produced.

(*d*) *Pour a few drops of iodine solution upon a slice of raw* potato. Notice the blue coloration showing the presence of starch. Repeat with other articles of diet.

(*e*) Scrape the fresh cut surface of raw potato with a knife. A milky liquid is produced. Mix a drop of this liquid with a drop of water on a microscope slide and cover with a cover glass. Examine with the lower power of the microscope. Make drawings of the starch grains seen.

On the microscope slide, close to the side of the cover glass, put a drop of iodine solution, and by means of a glass rod make the iodine solution run to the edge of the cover glass. By means of a piece of blotting-paper suck away the liquid from the opposite edge of the cover glass. This draws the iodine solution under the glass and in contact with the starch grains. Note the blue colour of the starch grains.

(*f*) Using finely-powdered wheat, flour, rice, oatmeal, tapioca, arrowroot, and peas, repeat the above experiment. It will be best to use the higher power of the microscope for some of these, as the starch grains are small. Make drawings of the various grains.

IV. Sugar.—(*a*) Taste a little dextrose (glucose). Notice that it is sweet, but not so sweet as ordinary cane sugar. Dissolve a fragment in some hot water in a test-tube, and add an equal quantity of Fehling's solution, and boil. A red precipitate of oxide of copper is produced. This is a characteristic test for glucose.

(*b*) Repeat the above experiment with a solution of cane sugar. No result is obtained.

(*c*) Repeat also with a solution of starch. No result is obtained.

(*d*) To some starch solution in a beaker add a few drops of dilute sulphuric acid. Boil for about twenty minutes. Now test a small quantity of the liquid with iodine solution. Notice that no blue colour is produced. To another portion add Fehling's solution, and boil. The production of the red precipitate shows that the starch has been converted into glucose.

(*e*) *Make a dilute solution of cane sugar (about a quarter of* a teaspoonful in half a teacupful of water), place in a flask, add five or six drops of strong hydrochloric acid, and heat the flask on a water bath for half an hour. Then pour into a dish and add while stirring carbonate of soda solution until no effervescence occurs. To a portion of the liquid apply the Fehling's solution test and note the production of the red precipitate, showing that glucose has been formed. The process is called the "inversion" of the cane sugar, and the product is called "invert sugar."

CHAPTER VI

THE DIGESTIVE SYSTEM

1. Introduction: The Alimentary Canal

The food we eat is subjected to a great many processes before it is really assimilated by the body. Some of these processes are merely mechanical or physical, and are very simple, while others are complicated chemical actions.

The food is first broken up thoroughly by the teeth, and while this is going on it is being acted upon chemically by the saliva. It is then forced through a funnel-shaped cavity at the back of the throat, called the pharynx, into the oesophagus, or gullet, down which it passes on its way to the stomach. In the stomach it is again subjected to chemical changes. From the stomach it passes along the intestines, where it is still further acted upon. Absorption of digested material is going on all the while, from the moment the food enters the intestine.

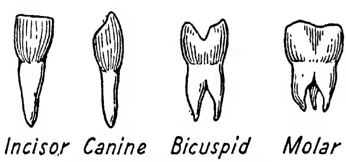

Fig. 39. KINDS OF TEETH.

The whole passage along which the food passes, from the mouth to the end of the last (or large) intestine, is called the **alimentary canal.**

2. The Teeth

The teeth are divided into four classes according to their shape. In front are the **incisors**—the flat sharp-edged biting teeth. The long narrow fang-like teeth at each side of the incisors are called **canines.** Still farther along the jaw are

teeth which seem *to* be *partly split* into two at the bottom—these are the **bicuspids.** The **molars** are the broad-topped grinding teeth which are placed at the back.

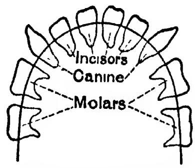

Fig. 40. Milk Teeth (Upper or Lower Jaw).

There are two sets of teeth, the first set or the **temporary teeth,** and the second set which are more or less **permanent teeth.**

The first set are also called the **milk teeth.** They are twenty in number, and consist of eight incisors, four canines, and eight molars; each half of each jaw being provided with two incisors, one canine, and two molars. This set is usually complete at three years. They begin to drop out about the seventh year, and have all gone at twelve. By the fourteenth year all the permanent set have appeared except the last four molars, called the **wisdom teeth.** These may not be cut until the twenty-fifth year.

The permanent teeth are thirty-two in number, and are divided into eight incisors, four canines, eight bicuspids, and twelve molars. At about fourteen years there would be twenty-eight teeth, the last four molars not being cut at this age.

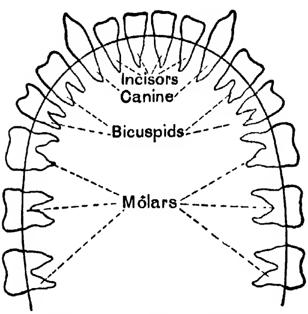

Fig. 41. Permanent Teeth (Upper or Lower Jaw).

3. Structure of a Tooth

Each tooth consists of a **crown,** or the part showing above the gum, and the **root,** or the part imbedded in the jawbone. The root consists of one or more fangs. A slight constriction is visible at the line where the crown

and the root meet; this is called the **neck.** The main bulk of a tooth is made of a substance called **dentine,** which closely resembles bone in its structure and composition. Covering the crown of the tooth is a layer of extremely hard material called **enamel.** It differs from ordinary bone by containing a less percentage of animal matter: it is hard and resists decay. The fang of the tooth is covered by a bony layer called **cement,** which fixes the fang securely in its socket in the jaw.

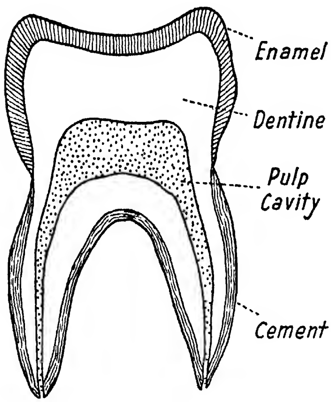

Fig. 42. Section of a Molar Tooth.

In the body of the tooth is a cavity which is filled with a pulpy substance containing nerves and blood-vessels. These enter the tooth at the tip of each fang, and pass into the **pulp cavity.** Ordinary toothache is caused by the inflammation of this pulp in the tooth.

4. The Salivary Glands

There are three pairs of these glands. Small tubes or ducts lead from each gland, and the saliva trickles along these into the mouth. Each pair of glands has a special name. Those placed in front of and below each ear are called the **parotid** glands; another pair, close to the inner side of the lower jaw on each side, are called the **submaxillary glands**; the third pair are placed under the tongue, and are called the **sublingual** glands. These glands are lined with cells which secrete the saliva, the flow of which into the mouth is increased by placing food there, or even by the sight or smell of food.

Saliva is an alkaline liquid made up of water, salts, mucus, and a peculiar substance called **ptyalin**—a **ferment.** This is the first example we have had of an important class of bodies called ferments. They have the property of causing remarkable changes to go on in various substances around them when the conditions are favourable. Ptyalin causes the starch in food to unite with water and become changed into sugar.

The saliva also serves to moisten the food and thereby assists mastication. After the food has been thoroughly broken up by the teeth and moistened by the saliva, it is collected into a mass, and is forced through the pharynx into the oesophagus. By dissolving some of the constituents of the food the saliva aids the sense of taste.

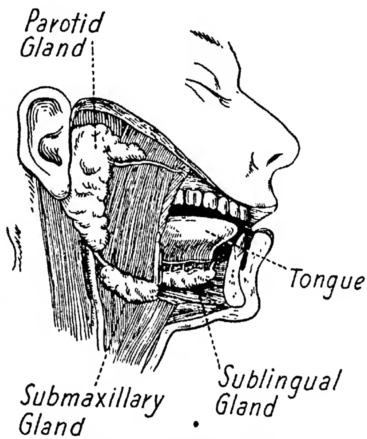

Fig. 43. Salivary Glands.

5. The Oesophagus

The oesophagus is a soft fleshy tube about nine inches long. It is the first part of the continuous tube—the alimentary canal previously mentioned—which extends from the mouth to the anus. It passes from the **pharynx** above to the stomach below. Owing to the softness of its walls, it does not remain open when there is no food passing down. The oesophagus plays no part in the actual work of digestion or absorption of the food.

6. The Stomach

The stomach may be described as a somewhat irregular dilation of the alimentary canal. It is situated in the abdomen, just below the diaphragm. It measures about ten inches from left to right. The enlargement is greatest on the left (or **cardiac**) end of the stomach. The right (the **pyloric**) end of the stomach becomes continuous with the first part of the small intestine (the **duodenum**). The upper border of the stomach is concave, and is sometimes called the **lesser curvature**, in comparison with the lower convex border, which is called the **greater curvature.**

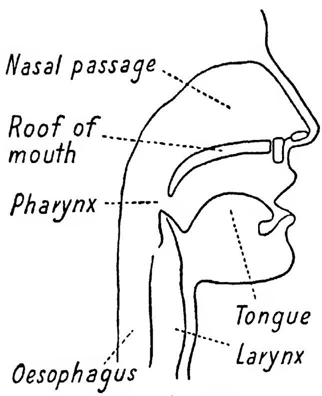

Fig. 44. PHARYNX.

The stomach is lined with a smooth, soft material called **mucous membrane.** The inner surface of the stomach is quite smooth when the stomach is full, but becomes thrown into ridges and folds as the stomach gets empty and contracts. The lining membrane is almost entirely made up of minute simple blind tubes running at right angles to its surface. These are called **tubular glands.** Between the tubules is connective tissue containing blood-vessels and lymphatics. The presence of food in the stomach causes the blood-vessels to dilate and to bring extra blood to the stomach. Then the cells in the tubular glands at once secrete a colourless liquid called the **gastric juice,** which is poured out into the stomach and mixes with the food.

Outside the mucous lining of the stomach is the **muscular coat**, which is divided into three layers according to the direction in which the muscular fibres run. At the exit from the stomach there are a greater number of circular muscular fibres than anywhere else, and here they form a sphincter, or "closing," muscle which prevents the food passing from the stomach until it has been properly churned up with the gastric juice.

The outer layer of the stomach is the covering which is common to all the organs of the abdomen. It consists of a smooth glistening membrane, called **peritoneum**.

Gastric juice is the liquid secreted by the glands of the stomach. It is a clear, colourless, acid liquid, containing water, salt, hydrochloric acid (0·2 per cent.) and a ferment called **pepsin**. The pepsin and the hydrochloric acid together act on the food and convert the protein part of it into **peptones**. Practically no absorption of digested food takes place in the stomach.

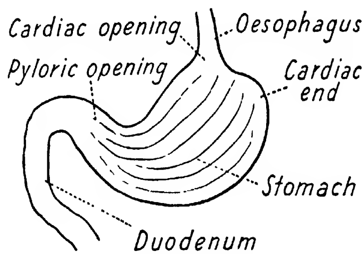

Fig. 45. Stomach and Duodenum.

7. The Small Intestine

The small intestine commences at the pyloric opening of the stomach and ends in the lower right-hand corner of the abdomen. The greater part of the small intestine is coiled up in the centre of the abdomen. When uncoiled it measures 21 feet. The walls are made up of three coats arranged in just the same order as those of the stomach. Inside there is a mucous coat, next a muscular coat, and outside this the

peritoneum. The mucous coat of the small intestine is thrown into large folds, some of them being a quarter of an inch in depth. These folds differ from the folds of mucous membrane in the stomach by *not* disappearing when the intestine is filled with food. By means of these folds the area of surface of the mucous membrane is very greatly increased.

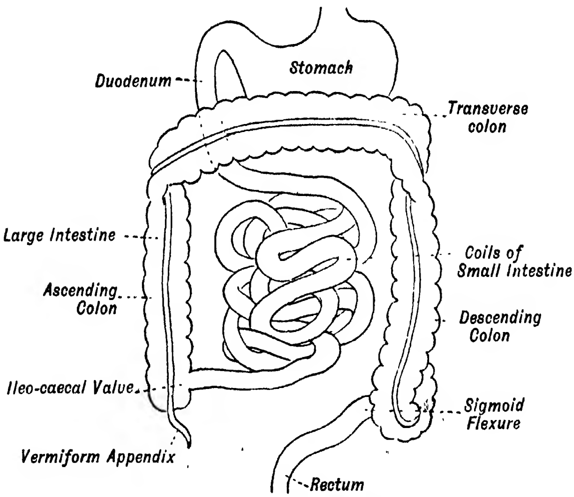

Fig. 46. Small and Large Intestine.

If a piece of small intestine is opened, put into water, and the inner surface examined with a magnifying glass, it will be seen to be covered with a great number of tiny projections like the fingers of a glove, which give the surface a velvety appearance and touch. These projections are called **villi.** Between the villi are small holes—the openings of small tubular glands, which secrete a liquid called **intestinal juice.**

The chief function of the small intestine is the absorption of digested foods. This is carried out by the villi. The intestinal juice is important as it helps to complete the digestive process.

8. The Large Intestine

The large intestine is about six feet in length. The small intestine enters it at the side, leaving a blind end, called the **caecum**, from which a narrow worm-like process is given off, called the **vermiform appendix**. Above the caecum comes the **ascending colon** which reaches to the under surface of the liver on the right side, then the **transverse colon** stretching across the upper part of the abdomen, and then the **descending colon** down to the left side of the pelvis. For the last few inches the intestine is comparatively straight, and is called the **rectum**. This opens externally at the **anus**. The anus is surrounded by a ring of muscle which normally keeps it closed. The muscle is under the influence of the nervous system, and controls the emptying of the bowels.

The chief function of the large intestine is to absorb what is left of the useful material of the digested food and also water.

9. The Liver and Pancreas: The Bile and Pancreatic Juice

We have now studied the structure of the long tube which connects the mouth and the anus, and we have seen that in its walls are various glands which have a digestive action on the food. These glands alone, however, would be insufficient to carry on the digestive process in the best possible way, and so there are connected with the small intestine two large glands—the **liver** and the **pancreas**—which secrete two very important liquids—the **bile** and the **pancreatic juice**. These two liquids are poured together into the small intestine near its commencement, and therefore are able to act upon the food as it passes from that point to the end of the alimentary canal.

The liver is placed immediately under the diaphragm, and its upper surface is convex, so as to fit the concave under side of the arch. It is the largest gland in the body, weighing about 50 ounces. It is usually dark red and fleshy looking, and is covered with peritoneum—the covering which is common to all the abdominal organs. It is divided into five lobes.

The under surface of the liver is irregular and fissured. If it is examined there are three great vessels seen to be attached. These are (1) the great artery bringing blood from

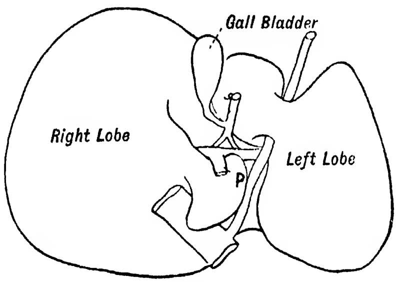

Fig. 47. The Under Surface of the Liver.
P = Portal Vein.

the heart; (2) a great vein bringing blood from the stomach, intestines, spleen, and pancreas; (3) the bile duct which conveys the bile from the liver to the small intestine.

The bile duct passes into the small intestine, but on its way it gives off a side tube leading to the **gall bladder,** which serves as a reservoir into which the bile may flow when it is not required in the intestine. The gall bladder is placed on the under-surface of the liver in front. When there is no food in the intestine the bile flows along the side duct into the gall bladder, but on food entering the small intestine the bile is discharged amongst it.

The bile is a yellow liquid containing water, mucus and salts. The bile is not a digestive juice in the same sense as saliva or the gastric or pancreatic juice. It is mainly an excretion which assists digestive action.

The pancreas, or sweetbread, is situated in the bend of the duodenum on the right, and stretches across to the spleen on

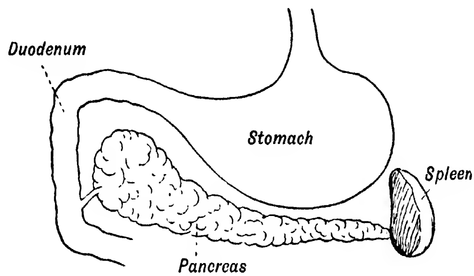

Fig. 48. The Pancreas.

the left. It is about seven inches long, and is of a reddish-yellow colour. The duct of the pancreas enters the small intestine at the same point as the bile duct.

Pancreatic juice is a colourless liquid composed of water, salts—chiefly sodium carbonate—and ferments. The ferments that are present enable the pancreatic juice to act upon all kinds of food.

CHAPTER VII

DIGESTION AND DISPOSAL OF FOOD

1. The Process of Digestion

We have seen that the food may be divided up into water, salts, proteins, fats, carbohydrates and vitamins, and it now remains for us to trace each constituent in its journey through the alimentary canal, the blood stream, the tissues and the excretory organs.

The water that we drink is probably absorbed into the blood-vessels all along the alimentary canal. The salts accompany the water into the blood stream and, in growing children, are used up to manufacture bone and other tissues requiring salts. Part goes, as we have seen, in producing the hydrochloric acid of the gastric juice, the iron of the haemoglobin, etc. Eventually the salts are excreted by the body, some in their normal form, but others with an altered composition. The salts are got rid of in the sweat, the urine and the excreta from the intestine. The water is expelled through the same channels and in addition a large quantity is excreted with the breath.

2. The Action in the Mouth

The solid part of the food is broken up by the teeth, and at the same time is mixed with the saliva. The ptyalin in the saliva slowly converts the starch into grape sugar. At the same time the sugar and the salts present dissolve in the saliva. As the time during which the food remains in the mouth is somewhat limited, it is obvious that this conversion of starch into sugar is necessarily only on a small scale.

3. Action in the Stomach

The food is then swallowed, and reaches the stomach. Here it is quickly mixed with the gastric juice which, being

acid, puts an end to the action of the saliva, because ptyalin is destroyed by acids. The pepsin in the gastric juice, together with the hydrochloric acid which accompanies it, converts the proteins into peptones. Peptones differ from other proteins in being very soluble and are, moreover, diffusible, that is, they are able, dissolved in water, to pass through a membrane from a solution rich in them to a solution poor in them.

The muscular coats of the stomach contract, first in one part and then in another, and so move the food about and churn it up thoroughly with the gastric juice. This churning goes on until the whole of the contents of the stomach is brought to a semi-fluid consistency. The turbid fluid that thus results is called **chyme.** The gastric juice has no action on carbohydrates or on fats, but it assists the digestion of these bodies by dissolving away the proteins with which they are mixed. It also dissolves the protein walls of the fat cells, while the warmth of the stomach melts the fat.

4. Action in the Small Intestine

After a variable time—usually between three and four hours—the chyme passes into the duodenum, or first part of the small intestine. Here it is acted upon by three important liquids—the bile, the intestinal juice, and the pancreatic juice. The first effect of these liquids is to make the acid chyme alkaline. This stops any further action of the pepsin. The pancreatic juice, by means of the ferment **amylase,** then converts any starch that may be present into malt-sugar. Any proteins that have escaped the action of the gastric juice are also attacked by the pancreatic juice and converted into peptones. The peptones and the sugar pass directly into the blood-vessels which lie in the villi. The bile has no action on proteins or starches and, as indicated above, is mainly an excretion, but it accelerates the action of the fat-splitting ferment of the pancreatic juice, known as **lipase,** which acts four or five times more rapidly in the presence of bile.

In the small intestine the fats are broken up into tiny droplets like the form in which fat exists in milk, thereby forming a milky fluid (emulsion). This action is aided by the pancreatic juice and the bile.

The small intestine is concerned mainly with the absorption of food-stuffs which are moved along by a peculiar movement called *peristaltic contraction*. The circular fibres of the intestinal wall at any place contract, thereby decreasing the capacity of the intestine there, and so squeezing out the greater part of the contents at that point. This contraction is next taken up by the fibres adjoining these, and then by their neighbours, and so on, the contraction passing along the intestine like a wave, and always towards the large intestine.

5. Action in the Large Intestine

By the time the food reaches the end of the small intestine it is semi-fluid, and has very little serviceable material left in it. It passes into the large intestine. Here the remains of the useful material are absorbed, together with the greater part of the water. As the contents are passed along they become more and more solid, until the remainder, chiefly the indigestible part of the food, is discharged from the rectum.

6. Food Changes: Weight

It is sometimes useful to consider the process of digestion from another standpoint, namely, by considering each chief food-stuff separately. Starch is acted upon in the mouth by the saliva, and is converted into sugar; a similar change of starch into sugar is also carried on by the pancreatic juice in the small intestine. Proteins are changed into peptones by the gastric juice in the stomach, and by the pancreatic juice in the small intestine. Fats are emulsified in the small intestine by the pancreatic juice.

After it is digested, the food reaches the blood. Eventually all the food becomes changed into carbon dioxide, water, and urea, but this change may either be brought about very

quickly or may be postponed for a long time by the food being converted into the tissues of the body.

The net result of the above digestive processes is that in the case of children there is a gradual gain in weight, while in the case of adults the weight remains practically stationary. If a child is weighed at intervals the weight is found to increase, although between meals there is a loss. If an adult is weighed at short intervals it is found that there is a continuous loss of weight between meals and a gain immediately after a meal. The net result in twenty-four hours is that the weight is the same. If no food is taken there is loss of weight.

PRACTICAL WORK

I. The Action of Saliva.—(*a*) Mix a small quantity of starch with water, and boil it. Add water, if necessary, to make it rather thin. Let it cool, and then add to a small portion of the liquid a few drops of iodine solution. A blue colour is produced. This is the test for starch.

(*b*) To another small quantity of the solution of starch add a little of your own saliva, and keep the liquid at about the body temperature for half an hour. The liquid becomes thinner and more watery. Pour a small quantity into a test-tube and add iodine solution again. This time there is no blue colour formed: this shows that the starch has disappeared.

(*c*) Taste the liquid formed by the action of the saliva on the starch. The sweetness tells you that the starch has been turned into sugar. To test for sugar, add a little Fehling's solution and boil. A red precipitate is produced.

II. The Action of Gastric Juice.—(*a*) Make a solution of white of egg in water. Add to it one drop of copper sulphate solution and some solution of potassium hydrate. A violet colour is produced, which is a characteristic reaction for albumin and globulin.

(*b*) Use another portion of the solution of white of egg, and add to it some of the artificial gastric juice prepared from the pig's stomach. Keep the test-tube at about the same

temperature as the body for half an hour. Then add one drop of copper sulphate and some potassium hydrate solution. This time a rose-coloured solution is produced, showing that a peptone is present.

(*c*) Into another part of the prepared gastric juice put a few fragments of hard-boiled white of egg and keep the tube at about the body temperature. In less than an hour the white of egg will probably have disappeared. It has been changed into peptone, which may be identified as in (*b*).

(*d*) To some milk warmed to about the body temperature add some rennet (obtained from the calf's stomach). In a short time the milk clots and forms a junket, which is a pleasant and nutritious food. The rennin ferment in the stomach causes the clotting of all the milk that is swallowed.

CHAPTER VIII

DIETS. EXAMPLES OF FOODS

1. Meals

The quantity of food that is necessary will vary greatly according to the climate, the age, the sex, and the amount and nature of the work that has to be done. For example, a larger amount of all kinds of food, but more especially heat-producing food, is required in cold climates and for laborious occupations. Also, women are said to need generally one-tenth less food than men; but if such is really the case, it is probably only due to the fact that their work is of a much lighter character than men's work.

The method of taking food is of very great importance. All food should be chewed thoroughly and slowly before it is swallowed. The habit of reading and studying during meals should be discouraged in favour of bright conversation, but the reading of light literature during a solitary meal is probably beneficial. *Large* quantities of fluids should be avoided at meals, as they dilute the gastric juice, and prevent or retard its action on the food. A short rest after meals, before resuming work, undoubtedly aids digestion.

With regard to the *times of meals*, the chief points that deserve attention are regularity and the observance of a proper interval between successive meals. Very long intervals are undoubtedly injurious, but the other extreme is harmful and is far more common, especially among women. It is found that an ordinary meal remains in the stomach for about four hours, and is then passed on. This interval should therefore be the minimum one between any two successive meals. Three meals are sufficient, and more than four per day should never be taken. The last meal should be taken not less than one or two hours before going to bed.

A few of the foods in daily use will now be considered.

2. Milk

Milk is a liquid consisting of emulsified fat, water, proteins, salts, carbohydrates and vitamins, and having a density of 1,032 (water being 1,000), which means that it is heavier than water. The proteins are mainly casein and a little albumin; the carbohydrate is milk sugar. The salts include phosphates of calcium, potassium, and magnesium. It is obviously a perfect food because it is the sole nourishment provided for the young of the higher animals.

With regard to its composition, it is important to notice that milk contains representatives of the five great food classes —proteins, fats, carbohydrates, mineral salts, and vitamins, as well as water. The average composition of cow's milk is given below, and for the sake of comparison the composition of human milk is given at the same time.

Milk.	Water.	Sugar.	Proteins.	Fats.	Salts.
Cow's	87	4·5	4	3·8	·7
Human	87	6·5	2·2	4	·3

Human milk therefore contains more sugar than cow's milk, but less proteins and salts—hence the general rule of diluting cow's milk and adding a little sugar when preparing food for infants.

Milk very readily sours, and it is little wonder that industrial chemists early devoted themselves to converting it into something with better keeping qualities and less bulk. Obviously the thing to do was to get rid of the 87 per cent. of water. Success has attended their labours, and dried milks are now widely used.

When milk is allowed to stand, about 10 per cent. of its volume should rise to the top as cream. The cream consists of the greater part of the fat, together with a small amount of the other constituents. The liquid left after skimming the milk is called "skim milk," and contains casein, milk sugar, and salts. "Separated milk" is similar to skim milk, being the residue left after cream has been removed by

centrifugal force. By adding rennet or very weak acid to milk it is separated into a solid called the curd, and a clear liquid called whey. The solid consists of coagulated casein with the fat and some of the sugar and salts. The whey contains milk sugar and salts.

When milk is boiled, the albumin is coagulated, and other rather obscure changes are produced, which cause the milk to possess an altered flavour. The coagulated albumin collects on the top as a kind of skin. The most important effect of boiling milk is the destruction of all kinds of microbes that the milk may contain. For this reason milk should always be boiled before being used, unless its purity can be relied upon. The process of boiling should be as short as possible.

Boiled milk is more digestible than fresh milk; it is, however, less palatable to most people, and no doubt loses some of its dietetic value and some important salts in boiling. But whatever disadvantages boiled milk may have, they are outweighed by the protection secured.

3. Diseases Connected with Milk

It is a well-known fact that if milk is allowed to stand for some time it turns sour and forms curds. Sour milk is liable to cause sickness and diarrhoea in children.

It is possible for certain diseases from which the cow suffers to be transmitted through the milk; milk containing the germs of tuberculosis, for instance, gives rise to tuberculosis in children to an extent which constitutes a blot upon the health administration of this country.

Milk, moreover, may frequently act as a carrier of infection from other human beings, and owing to the present incomplete system of dairy inspection it is advisable to avoid risk by scalding all milk unless it has been pasteurised or unless it is what is known as "certified" or "grade A (T.T.)" milk. The disadvantage of pasteurisation in bulk by milk purveyors is that the process may be used to cover up a dirty and unsatisfactory milk supply.

In addition to the danger mentioned above of disease being transmitted from the cow, there is always the possibility of:—

(1) Accidental contamination from an outside source, such as may happen when scarlet fever or diphtheria occurs at the dairy or farm, or at the house of one of the workpeople.

(2) The washing of the milk cans or other vessels with water which has become contaminated in some way.

(3) The milk being, in some cases, adulterated with such contaminated water.

In those epidemics of scarlet fever which have been traced to milk, it is usually found that the milk has been infected through human agency by a previous case of the disease at the farm or dairy.

It has also been proved that the milk from cows suffering from tuberculosis can convey that disease to pigs as well as to young children.

4. Eggs

As the chick is developed from the egg it is obvious that the egg must contain everything that is required for the construction of the body. A hen's egg consists of 70 per cent. of water and 30 per cent. solid matter. Of the solids, the white is mainly albumin; the yolk contains fat, albumin, and phosphates. Eggs form a very valuable article of diet, being rich in proteins, fat, and vitamins. They should never be over-cooked, because hard-boiled eggs are indigestible to some people.

A stale egg is easily detected by testing whether it will float or not in a solution of two ounces of common salt in a pint of water: a new-laid egg sinks in this liquid.

To *preserve* eggs they should be coated over with wax, lard, or such like, while they are fresh, or they may be immersed in a solution of " water-glass."

5. Cheese

Cheese is a food rich in nitrogenous matter. It consists of coagulated casein, with varying quantities of fat and salts. It is a most valuable food and, generally speaking, it represents better value for money than most other foods.

6. Butter and Margarine

Butter is almost pure fat. It is obtained by churning cream that has been skimmed from milk. The liquid left behind is called buttermilk, and still contains enough of the original constituents of the milk to make it a good food, especially if eaten with some starchy substance such as potatoes.

Margarine as originally prepared from beef-fat, flavoured and coloured to resemble butter, contained some Vitamin A. It is now commonly made from vegetable oils, and contains little or none, so that it must be regarded as an incomplete substitute for butter. It is none the less a cheap and valuable food.

7. Meat, Fish, and Poultry

MEAT.—These are nitrogenous foods, containing variable quantities of fats, salts, and vitamins, but practically no carbohydrates. As a general rule these foods are more easily digested than those of vegetable origin.

Beef is more nutritious than mutton or pork, and at the same time it contains a less proportion of fat. The best beef is that which is obtained from a young ox. Veal is far less digestible than beef, and is also less nutritious.

Mutton has a shorter fibre and is usually more easily digested than beef. The mutton from a three-year-old sheep is the best. Lamb is more watery and less digestible than mutton.

Pork is very difficult to digest owing to the large quantity of fat that is present. The muscle fibres are hard and are surrounded with fat. Bacon is much more digestible than

pork, and is one of the best of the foods containing an excess of fat.

Frozen and Chilled Meat.—Meat arrives in this country from Australia frozen solid and hard at about 10° F. or 22° below freezing point. This is called "frozen meat." For shorter periods it is possible to preserve meat during transport by keeping it 1° or 2° below freezing point. This is called "chilled" meat, and is more like fresh meat than the frozen variety. Frozen meat should be slowly thawed for about two days before use. There is little or no difference in the nutritive value of these meats and the home-killed varieties.

Frozen or chilled meat may be distinguished by the following characteristics:—(1) The colour of the meat is either pinker or darker and is more uniform; (2) the fat is often stained pink or red; (3) it feels softer; and (4) the external surface is rather brown and dull in appearance. In chilled meat the surface is dull and greyish.

Good meat should present a marbled appearance, brownish-red in colour, firm and elastic, without any odour. Bad or unwholesome meat may be too pale or too dark, is unduly moist and flabby, pits on pressure, and has an offensive smell.

Fish.—Fish must be eaten fresh, unless it is specially cured. A fresh fish is firm and stiff, the eyes and the scales are bright. The surface should be unbruised and unbroken.

The flesh of fish contains more water and less nitrogen than butcher's meat, but it forms usually a digestible and cheap food.

Fish are conveniently divided into the white and the red varieties. The commonest example of the red fish is the salmon, which contains rather a large proportion of fat, and is not easily digested. The white fish are divided into those which contain fat and those which contain no fat at all. The cod contains no fat, and its fibres are hard and difficult to digest, but this fish has the remarkable power of storing up Vitamins A and D in its liver. The oils prepared from the liver of the cod and its allies are the richest known source of

these vitamins. Of the fish which contain fat, those which contain the least are the most digestible. Thus, whiting and sole contain less than one-half per cent. of fat and are very light and digestible; mackerel with 6 per cent. fat are less digestible; eels with 24 per cent. of fat are rather indigestible.

Among the shell-fish, crabs and lobsters are notoriously indigestible; oysters are easily digested, but the nutritional value of oysters is not high. It would take 14 of them to contain as much nourishment as one egg. Mussels, scallops, and cockles are similar in composition to oysters, and cannot be regarded as foods of important nutritive value.

POULTRY.—Poultry and game contain little fat as a rule, and are easily digested. Ducks and geese have more fat than the others, and are less digestible. Hares and rabbits have much the same value as poultry.

8. Diseases Caused by Meat

In some cases symptoms of poisoning have been set up by eating cooked meat. This is especially the case with sausages, potted meats and pies, and fish. These effects are probably not produced by decomposition, but by poisons formed by certain bacteria, and even thorough cooking may not entirely remove the danger from these poisons. Shell-fish taken from beds which may be contaminated with sewage have in many cases produced illness.

Parasitic diseases are sometimes conveyed by imperfectly cooked meat, but this is only likely to happen abroad, where many forms of partially cooked meat are popular.

9. Vegetable Foods

These foods usually contain proteins, starch, sugar, and fats in varying proportions. As a rule, however, the starch or the sugar is very greatly in excess. The only vegetables that contain any important amount of proteins are the pulses—peas, beans, lentils, etc.—which contain over 20 per cent. of

proteins, and some of the cereals—wheat, oats, barley, and maize—which contain more than 10 per cent. of proteins. The proteins present are mainly albumin, legumin, or gluten.

It is usual to divide vegetable foods into six classes—(1) the cereals; (2) the pulses; (3) roots; (4) green vegetables; (5) fruits; (6) edible fungi.

(1) Cereals.—The **cereals** include wheat, oats, barley, rye, maize, and rice. Wheat contains a large quantity of gluten, which gives wheat flour the property of being made into a coherent dough, and then into bread. With the exception of rye, the other cereals contain too little gluten to make bread without mixing first with wheat flour. In the preparation of wheat flour some of the outside shell may be retained with the flour when brown bread is required, or separated entirely in the form of bran when the flour is to be used for white bread. The retention of the germ of the grain increases the nutritive value of the flour.

Oatmeal is highly nutritious if well cooked. It contains proteins, fats, starch, and salts.

Rice is poor in everything except starch, as it contains very little protein, fat, or salts.

(2) Pulses.—The commonest **pulses** are peas, beans, and lentils. They are distinguished from all other vegetables by possessing a large proportion of a protein called legumin. They are the richest protein foods obtainable, except cheese; they approach more nearly to perfect foods than any other vegetables, and are rich sources of vitamins. Unless very well cooked, however, they are somewhat difficult to digest, and are often the cause of flatulence. If combined with fatty foods, such as bacon, they are very important articles of diet, and are especially useful for making soups, for which purpose lentils are the best.

(3) Roots.—The various **roots** and **tubers** are composed largely of starch. Potatoes, carrots, and swedes are valuable sources of both Vitamins B and C.

(4) Green Vegetables.—Whilst **green vegetables** contain very little nutritive material, they are valuable, chiefly on account of their vitamin content. We include in this group cabbages, cauliflowers, lettuces, vegetable marrows, tomatoes, etc. They give variety and relish to the food. Another rather important use of these foods is due to the **cellulose** they contain. This is a substance resembling starch, but it is indigestible: it is useful, however, in forming a bulk in the intestines, thereby stimulating their movements and preventing constipation. The onion, leek, shallot, etc., possess essential oils which are useful in flavouring food.

(5) Fruits.—Most **fruits** are rich in salts of potash and Vitamin C, and are valuable on this account. Many of them have a considerable amount of sugar, and a few—the banana, date, and fig, for example—are nutritious on account of the sugar and starch they contain. Raw fruit should only be eaten when quite ripe and perfectly fresh. Unless the skin is discarded fruit should always be cleansed before being eaten.

(6) Edible Fungi.—The **edible fungi**, such as mushrooms, contain about 91 per cent. of water and a little nitrogen. Although not used much in this country, they form a valuable addition to diet in many countries, as in Germany. The poisonous fungi resembling mushrooms need careful recognition, and a small book published by the Board of Agriculture and Fisheries will be found useful.

10. Food Preservation

Food " goes bad " because it is invaded by certain bacteria which bring about certain chemical changes. These bacteria need (*a*) a suitable temperature; (*b*) the presence of moisture; and (*c*) the presence of air is usually necessary also. Many methods of preserving foods are based on these facts.

(1) Canning.—This is the method of preservation most commonly adopted and, if carried out with suitable precautions, it should be regarded as the safest and best. The success of

the process depends on the cleanly handling of the food prior to the canning, the complete exclusion of air during the heating process, and the efficient sealing of the can. Modern canning should not affect the vitamins in the food to any great extent, if any. Tins are far superior to glass containers, but a tin once opened should never be used to contain the food: the contents should be turned out into a dish or basin.

(2) COLD.—Bacteria are not destroyed by cold, but they are made inactive, and do not multiply. All kinds of foods may be kept almost indefinitely at low temperatures. Frozen meat is kept at about 10° F.

(3) DRYING.—By removing moisture it is possible to prevent decomposition of fruit, milk, eggs, meat, and a great variety of foods which soon go bad in their ordinary condition.

(4) SMOKING.—This is sometimes added to a partial drying process in the case of bacon, ham, and fish. This forms a preservative dry layer on the outside.

(5) CHEMICALS.—In salting and pickling processes the active agents used are salt, sugar, and saltpetre. In jam making the mixture is sterilised by the boiling and the sugar acts as a preservative.

The addition of chemical preservatives such as borax, boracic acid, benzoic acid, salicylic acid, and formaldehyde is strictly controlled by law.

11. The Feeding of Infants

An infant should be fed at the breast until it is eight or nine months old. If for some reason or other the mother cannot suckle her infant, then the child must be fed from the bottle; but it should be distinctly understood that the child will thrive most on the mother's milk, and that rearing a child by the bottle means that additional risks are run. If the breast milk fails, cow's milk is the only suitable substitute which can be easily obtained.

Dried milks have of recent years been much advocated, and most experienced medical men are agreed that dried milk is a better substitute for human milk than condensed milk or raw milk of doubtful quality. Milk made by adding water to dried milk has the advantage that the clots formed when it meets the acid stomach juices are smaller than those which occur with fresh cow's milk, so that the dried milk is frequently more acceptable to the baby's stomach and more easily digested.

Babies fed on boiled milk or dried milk need some addition to their diet in the form of fruit juices, which supply the necessary vitamins.

12. Diet for Invalids

During and after illness the digestive powers are weak, and great care should be taken in the judicious selection and preparation of the food. As a rule it is advisable to supply the food frequently and in small quantities. In fevers, liquid foods should be given, the most valuable being milk, beaten-up eggs, soups, and beef tea. Cooling drinks are also necessary, such as lemon water, soda water, etc. In any case of prolonged or serious illness, however, the advice as to diet given by a doctor or trained nurse should be followed.

13. Overfeeding

This is a common occurrence both in adults and in children. An excess of food in the case of an adult, due to unduly rich food or to too frequent meals, tends to cause indigestion and flatulence. If overfeeding be persisted in, the blood pressure tends to become raised and a train of events may be set in course which is likely to result in disease of the arteries and kidneys. Temperance in eating is just as conducive to health and long life as is temperance in the use of alcoholic beverages.

The overfeeding of infants is harmful. This generally results from departures from the time-table of feedings which

should be adhered to punctually and without any exception whatever. On no account should an infant be given the breast or bottle to quiet it; the cause of the crying should be ascertained and put right. If it be due to hunger then the bulk of the feed may require to be increased or the time-table adjusted. More often, especially in hot weather, the crying is due to thirst, which should be satisfied by a drink of water and not by milk.

14. Underfeeding

Continued, but moderate underfeeding deprives the body of its powers of resisting fatigue and disease. Protracted gross insufficiency of diet is followed by wasting of the tissues. Fatty tissue is naturally the first to suffer, and may be almost completely absorbed, and then those parts or tissues which are not vitally necessary in order to carry on life are sacrificed. Physical and mental weakness ensue, accompanied by a debilitated condition that powerfully predisposes to disease. Diarrhoea is apt to occur, adding still further to the general emaciation and prostration. Ophthalmia, ulcers, and skin diseases of various kinds are common, and any disease that may have obtained a hold upon the system is aggravated by the impairment of nutrition. Death ensues when the loss reaches about 40 per cent. of the normal weight of the body.

It is important to realise, however, that serious malnutrition may exist without pronounced loss of weight. The first effect of lack of adequate nourishment is lack of energy and lack of resistance to infection.

15. Illness Caused by Foods

This has been referred to in preceding pages. To summarise, health may be affected by food in the following ways:—

(1) Poisonous metals may be absorbed by food from metallic containers, *e.g.* tin and lead. This is not common.

(2) Injurious substances may be added intentionally or accidentally in the course of manufacture or distribution, *e.g.* arsenic in beer, copper in preserved peas.

(3) The flesh or milk of an animal suffering from certain infective or parasitic diseases may impart the disease: for instance, encysted tape-worm, or tuberculosis, in meat.

(4) A food may be contaminated by infection from a human source, such as milk or ice-cream infected by typhoid fever microbes.

(5) Careless handling in production may result in a dangerously polluted article such as dirty milk.

(6) Food poisoning may occur from contamination of food by those microbes which are capable of setting up poisonous symptoms in the human subject.

(7) Certain foods are definitely poisonous, such as poisonous fungi.

(8) Some foods are harmful in excess owing to their containing narcotic or poisonous substances, *e.g.* alcoholic beverages.

PRACTICAL WORK

I. Milk.—(*a*) Fill a test-tube with new milk and put it aside for twelve hours. Note the formation of cream on the top, and estimate roughly the proportion of cream to milk. Remove the cream with a pipette, leaving skim milk in the tube.

(*b*) By means of a lactometer ascertain the specific gravity of (i) new milk, (ii) skim milk, (iii) new milk with about $\frac{1}{10}$th of its volume of added water, and (iv) skim milk with about $\frac{1}{10}$th of its volume of added water. The specific gravity of new milk is usually about 1,030, reckoning water as 1,000. By removing cream (the lightest part of the milk) the specific gravity of the skim milk is raised to about 1,035. By adding water to milk its specific gravity is lowered. By removing cream and also adding water the specific gravity can be kept at about 1,030, so that the specific gravity alone is of little value as a test of the purity of milk.

(*c*) To a cupful of milk, warmed to about the body temperature, add a teaspoonful of essence of rennet, and after stirring, put it aside. The milk rapidly sets to a solid (curd). If the curd is broken up a watery liquid separates from it (whey).

(*d*) Dilute a small quantity of milk with an equal volume of water; add a few drops of vinegar, or dilute acetic acid, until a slight precipitate is formed. Then warm the liquid gently (do not boil). Filter. The white solid left on the filter paper is mainly **casein.**

(*e*) By keeping some milk for a few days a sample of sour milk is obtained. Test this with blue litmus. The reddening of the litmus shows that an acid has been produced.

(*f*) Butter may be produced by shaking some cream in a wide-mouthed bottle, or by beating cream with a wooden spoon.

(*g*) Place a drop of milk on a microscope slide, cover with a cover-slip, and examine under the low and also the high power. Note the small clear round globules of fat (emulsion).

II. EGGS.—Prove the presence of albumin in white of egg, and in the yolk also, by mixing each with a little water and boiling the mixture in a test-tube. Albumin is coagulated by heat.

III. MEAT.—Press a piece of blue litmus paper against a piece of raw meat. The litmus is reddened, showing that meat has an acid reaction. When the meat has begun to decompose the reaction is alkaline and would then turn litmus blue.

IV. WHEAT FLOUR.—Take about three tablespoonfuls of flour, tie it in a double muslin bag, and gently knead it under water. For this purpose use a large basin holding about a quart of water. Eventually a sticky mass is left in the bag, and a milky liquid in the basin. The sticky mass is **gluten.** The milky liquid contains the starch.

CHAPTER IX

COOKING

1. Reasons for Cooking Food

These may be summarised as follows:—

(1) The food is rendered more attractive to the sight, taste, and smell. The appearance of raw meat, for example, is repulsive, whereas, when cooked, it not only looks far more attractive, but its smell is tempting, and its taste is pleasing. As a result of this the flow of the digestive juice is increased and the appetite is stimulated.

(2) It is an error to suppose that cooking increases the digestibility of the food. That is only true of vegetable foods. The digestibility of animal foods is diminished rather than increased by cooking. This is true at least of the chemical processes of digestion. But cooked food is more easily broken up by the teeth and attacked by the gastric juices than is raw food.

(3) Certain changes take place in the food when cooked. The most useful of these is, perhaps, the breaking up of the starch granules, without which we should not be able to digest the starch in our food.

(4) By means of good cooking a great variety in the preparation of food can be obtained; the same material may be prepared in many ways. This stimulates the appetite and the digestion, and prevents that disgust which always arises from an unchanged diet.

(5) The warmth of the food helps digestion, and has a reviving effect upon the system.

(6) Any germs of disease, or parasites, that may be present in the food are killed by cooking, provided such cooking be thorough.

(7) Putrefaction and decay are delayed by cooking. Every one knows that cooked food keeps better than uncooked.

2. The Cooking of Animal Food

There are six methods commonly employed, viz. roasting, broiling, baking, frying, boiling, and stewing.

(1) Roasting.—The joint should be first exposed to great heat by placing it close to the fire. The effect of the heat is to form a crust of coagulated albumin on the outside of the joint. This impermeable crust prevents the escape of the juices from the inside of the meat. In about ten minutes the joint should be drawn about twelve inches from the fire, and the cooking completed at that distance. To prevent it from scorching the joint must be kept constantly in motion, and the surface "basted" with fat. The general rule as to the time required to cook a joint is to allow a quarter of an hour for every pound, and a quarter of an hour over. This should be the minimum.

The roasting coagulates the albumin and myosin, and converts the connective tissue into gelatin, thereby loosening the muscular fibres. There are also the characteristic odorous compounds produced. The loss of weight during roasting varies from one quarter to one third, and is due mainly to loss of water.

(2) Broiling or Grilling.—Broiling or grilling is roasting on a small scale on the top of the fire. The scorching is greater than in roasting owing to the greater surface exposed to the heat. The chop or steak should be placed on a clean hot gridiron over a clear fire, and turned over every two minutes. The surface must not be pierced by any fork or skewer during the cooking.

(3) Baking.—In a well-ventilated oven the process of baking corresponds exactly to roasting, but meat baked in the old-fashioned non-ventilated oven has a flavour quite different

from that of roasted meat. The joint should be placed on a small wire table in the baking dish so as to prevent the meat soaking in the grease. The oven should be very hot at first in order to form the crust of coagulated albumin on the outside of the joint.

(4) Frying.—Frying is boiling a food in fat. The meat cooked in this way is usually soaked with fat and is indigestible. This penetration of the fat is prevented somewhat by having the fat very hot to begin with. This method is often used for fish, but boiled fish is more digestible.

(5) Boiling.—If the object of boiling is simply to cook the meat and retain in it all its flavour and nourishment, the method employed is precisely the same in theory as the method of roasting. The joint is plunged into *boiling* water, and the boiling is maintained for five minutes. This coagulates the albumin on the outside, and forms a coat through which the meat juices cannot escape. For the remainder of the time the water should not be allowed to boil at all, but should be kept at about 170° F., *i.e.* about 40° below the boiling point. If the water is kept boiling the whole time, the meat is made hard and indigestible.

The object of boiling the meat may be not only to cook the meat, but also to make good *broth*. In this case the meat is put into *warm* water, and the water is not allowed to boil at all—the meat being kept at about 170° F. the whole time. In this way the albumin is not solidified but dissolves in the water, together with a part of the meat juices. The meat when so cooked retains a considerable portion of the nourishment, but is rather more tasteless and less digestible and nutritious than when prepared by the first method.

Another object in boiling meat may be the preparation of a *soup*. In this process the object is to extract as much as possible of the nutritive principles from the meat. The meat should be cut up into small pieces and placed in

cold water. After it has soaked for some time, the heat should be applied very slowly, and the temperature gradually raised to about 170°. This temperature is maintained for two or three hours, and then it is brought up to boiling point for another hour. This treatment extracts practically all the nourishment from the meat—which is left as a hard, tasteless, stringy mass.

The difference between broth and soup is merely one of degree, soup obviously containing a greater proportion of the meat juices than broth.

To boil fish, water just below boiling should be used, as many kinds of fish would break if placed suddenly in boiling water. Care should for the same reason be taken to prevent the water boiling vigorously at any time.

Before dismissing the subject of boiling, it would perhaps be advisable to state here that water which is boiling very gently is just as hot as water which is vigorously bubbling.

(6) STEWING.—Stewing is by far the most economical cooking process, because by this method there is absolutely no waste. Unfortunately it is a process that is but little practised in England. Any kind of meat may be used. The meat should be cut up into slices, seasoned, placed in the stew-pan, and just covered with cold water or stock. It should never boil during any part of the process. Vegetables or flour are often mixed with the water to make it thicker and richer. By cooking in this way the meat is softened and made digestible.

The best possible results are obtained by using a water-bath for stewing. This simply consists of an inner and an outer vessel. The stew is made in the inner vessel, and the outer vessel is filled with water which is kept boiling. The water in the inner vessel remains just below boiling point all the while. If the stew is boiled, the meat becomes hard, tough, curled up, and indigestible.

For *hashing*, the same method should be adopted as for stewing, but in this case the meat has been previously cooked, and so extra care should be taken to prevent the liquid boiling.

3. Beef-tea

To prepare beef-tea properly, raw beef—free from fat—should be cut up into very small pieces, and put into a jar. A little salt is added, and cold water in the proportion of one pint to one pound of beef. The jar is covered with a lid and allowed to stand for two hours, after which it is placed for one or two hours in a pan containing boiling water, to heat the contents and remove raw appearance and flavour. The liquid should then be poured off from the beef, not strained.

Prepared in this way, beef-tea contains albumin, gelatin, salts, and extractives derived from the meat. It is a stimulating but costly food and should only be given on medical advice. Commercial meat-juices are similar in composition and value.

Meat extracts, so much advertised, are stimulating and appetising, but practically devoid of food value otherwise.

4. The Cooking of Vegetables

Potatoes should be placed in boiling water from the first. They are preferably either steamed or cooked with their skins on, because boiling in the ordinary way dissolves out the greater part of the salts that the potatoes contain. When thoroughly cooked, the starch granules swell up and burst, and part of the starch becomes converted into dextrin. Green vegetables should be cooked, if possible, in soft water.

5. Bread

On a small scale, the flour is mixed with a liquid consisting of warm water, yeast, and a little salt. The mass is then kneaded into dough, and is set aside in a warm place for three or four hours. The yeast sets up a process of fermentation, resulting in the formation of alcohol and carbon dioxide in the dough, making it light and porous. The dough is then made into loaves and baked. During the baking the starch granules are broken, and part of the starch is changed into sugar and dextrin. At the same time the gluten is coagulated.

Stale bread is more digestible than, but not so palatable as, new bread. Toasting bread makes it more easily broken up by the teeth and therefore more digestible. Pastry is much more difficult to digest than ordinary bread, owing to the starch granules being coated over with fat, which retards the action of saliva upon them.

6. Cooking Apparatus

All cooking utensils should be kept scrupulously clean and dry, by carefully scalding, cleaning, and drying after each time of use. The best substance with which to clean greasy cooking utensils is common washing-soda, and so all greasy pots and pans should be scrubbed thoroughly with a strong solution of it.

Special care should be taken to keep copper vessels dry and clean, and to cook nothing of an acid nature in them; such vessels are hygienic and economical of fuel. Aluminium vessels are also largely used to-day; washing soda should not be used for cleaning them. Galvanised iron vessels are undesirable, as the cooking of certain acid foods, such as apples, in them has given rise to zinc poisoning. The "double saucepan" with the inner vessel of glazed earthenware is a very useful cooking utensil, especially for cooking food containing acids, such as fruits. The ideal vessel is the modern glass casserole which is tough and almost unbreakable.

It was formerly taught that meat should always be roasted before an open fire, but the disadvantages of baking are now overcome by modern ventilated ovens. Open fires require more fuel than a closed cooking range.

Gas stoves are now widely used for cooking purposes. Their chief advantages are their cleanliness and the ease with which the heat can be regulated. They are rather more expensive than ovens heated with coal. The proper place for a gas stove is in the recess of an open fireplace, and it should not be placed in the open room unless it has a special

chimney made for it, to carry away the impure gases formed by the combustion of the coal gas, and also the smell of the cooking.

Electric cookers are becoming more and more popular in spite of the extra cost. No products of combustion are formed. This is the cleanest and healthiest cooker.

CHAPTER X

BEVERAGES

1. Non-alcoholic Stimulant Beverages

The stimulant beverages may be conveniently divided into *non-alcoholic* and *alcoholic*. The non-alcoholic are **tea, coffee,** and **cocoa.** These three substances each possess an active stimulating principle, the effect of which is somewhat similar in each case. The stimulating principle in tea is called **theine,** and this has the same composition as the active part of coffee, which is called **caffeine.** In cocoa there is a similar substance called **theobromine.** The action of these substances in moderation is to quicken and strengthen respiration and the heart's action. They also stimulate the nervous system and lessen fatigue and the desire for sleep, for which they are valued among brain workers. Cocoa contains much less stimulating properties than tea or coffee, its chief value being as a food and not as a stimulant.

Tea, coffee, and cocoa contain characteristic volatile oils, which give to each its distinctive and peculiar smell. Tea also contains about 14 per cent. of an astringent substance called **tannin,** to which are largely due its injurious effects when taken in excess.

2. Tea

Tea consists of dried leaves of the tea-plant, which grows in India, Ceylon, China, and Japan. Chinese teas are the best because they contain less tannin than the other varieties.

The tea-leaf yields to the boiling water chiefly theine, tannin, and volatile oil. The value of tea depends upon the theine it contains. This, as we have said, stimulates the heart, and respiration, and acts as a restorative to the nervous and muscular system. Its great value lies in the fact that

the stimulation produced by theine is followed by *no after-depression.* Tea has been found to be of great benefit to soldiers on active service, and in all cases where continuous exertion is required it is superior to alcohol as a stimulant. If prepared badly, or taken in great excess, it disorders digestion and gives rise to nervousness and palpitation. Tea should not be drunk too hot, and should not be taken with meat or cheese.

To Make Tea.—The tea-pot should first of all be made hot by partly filling it with boiling water, which is then emptied out again. The water that is used should be actually boiling, but if it has been boiling for some time previously the tea will not be so good. The water should be soft if possible, and when hard water is used a pinch of bicarbonate of soda may be added to it. Tea should not be allowed to stand for more than five minutes, and at the end of this time it should be poured off the leaves into another pot. If tea is brewed for a longer time than five minutes it is liable to contain excessive quantities of tannin, and is injurious.

3. Coffee

Coffee is the berry of a plant growing in Kenya, Ceylon, the West Indies, and other places. The seeds are roasted until they are of a dark brown colour, and are then ground to powder. Coffee contains caffeine, a little tannin, and some volatile and aromatic oils.

The action of coffee upon the body is very similar to that of tea. It stimulates the heart and nervous system, quickens breathing, and lessens the sense of fatigue and desire for sleep.

To Make Coffee.—The coffee should be freshly roasted and ground. About one ounce of coffee is required for making one large cup. The coffee-pot should be hot, and the water must be actually boiling.

Coffee essences or extracts are disappointing because they are usually adulterated with considerable quantities of chicory, caramel, and other substances which are useless as foods or

stimulants. There is no excuse for this except excessive greed for profits. With a world glutted with coffee, and with coffee growers bankrupt, there is no need for the present excessive retail price of coffee or for the existence of fraudulent coffee extracts.

4. Cocoa

Cocoa is the seed of a plant growing chiefly in the West Indies. The seeds are taken from the pod and allowed to undergo a kind of fermentation, during which the characteristic aromatic odour is said to be developed. The seeds are then roasted and deprived of their husks. Cocoa-nibs are the seeds broken up very roughly. "Prepared cocoa" is obtained by grinding the seeds, and afterwards removing the fat or cocoa butter, leaving the cocoa perfectly dry.

Cocoa contains theobromine, which is similar to theine and caffeine in composition and properties. It also contains starch, fats, nitrogenous bodies, and salts, and so it is to some extent a food. Obviously it resembles tea and coffee in having stimulating properties on a smaller scale; and differs from them in having some nutritive value.

Chocolate is prepared from cocoa by mixing with sugar and starch and pressing into moulds.

To Make Cocoa.—In making cocoa we do not prepare an infusion as in tea and coffee, but we drink the whole. Cocoa may be prepared with water, but it is much better when prepared mainly with milk. When it contains starch, cocoa requires to be well boiled, but if sugar only has been added it merely requires mixing with water or milk. If starch is present the cocoa thickens slightly on boiling.

5. Alcoholic Beverages or Fermented Drinks

Fermented drinks may be defined as those liquids which contain the products of a process of fermentation—the most important product being **alcohol.** The term "fermented

drinks" is intended to include **beers, wines, spirits,** etc. Their common constituent is alcohol, and they also contain variable quantities of sugar, acids, salts, and aromatic oils, which give to each its characteristic taste and smell.

In the preparation of these drinks either sugar or starch may be the starting-point. If starch is used, the first process is to change it into sugar. This change is usually effected by a ferment, which is present in malt. A solution of the sugar is then made, and the sugary liquid is fermented by adding yeast or some other ferment. The sugar is changed by the yeast into carbon dioxide and alcohol, and at the same time various ethers and acids are formed.

6. Beer, Ale, Porter, and Stout

Beers and ales are prepared in the above way, but hops or some other bitters are added. The definition of a beer or an ale should be that it is a fermented infusion of malt flavoured with hops. A very large proportion of modern beers are, however, prepared from sugar instead of malt, and other vegetable bitters are often added instead of hops. Porter is nothing more than a weak mild ale, coloured and flavoured with burnt malt. Stout is similar, but is rather stronger.

7. Wines

Wines are, or should be, prepared by fermenting the juice of the grape. They contain variable quantities of water, alcohol, carbon dioxide, ethers, colouring matter, vegetable acids, tannin, and sugar.

8. Spirits

Spirits are prepared by distilling a fermented liquor. (See Experiment II. (*b*) at end of this chapter.) **Brandy** should be made by distilling wine, but it is usually potato spirit; **whisky** by distilling the liquor obtained by fermenting malt with other forms of starch; **gin** in the same way, but with the

addition of oil of juniper, orange peel, and other aromatic substances: **rum** is obtained by distilling fermented treacle.

All spirits contain water, alcohol, and fusel oil, together with aromatic bodies which give to each its characteristic taste and smell.

9. Amount of Alcohol in Fermented Drinks

The amount of alcohol in fermented drinks varies very greatly. The following list gives roughly the proportion of alcohol present in some of the commoner beverages:—

Brandy	43 per cent.	Madeira	19 per cent.
Whisky	43 per cent.	Champagne	12 ,,
Rum	43 per cent.	Claret	8 ,,
Gin	37 ,,	Ale (Bottled)	7 ,,
Port	25 ,,	Porter	5½ ,,
Sherry	21 ,,	Beer	3 ,,

These figures refer to proportions by volume: for example, 100 pints of sherry contain 21 pints of alcohol.

10. The Effect of Alcohol

When alcohol is swallowed, it passes directly through the lining membrane of the stomach, and reaches the blood. The heart is stimulated and caused to beat more quickly and more forcibly for a time. Respiration is also similarly affected; in fact, all the organs of the body may be said to be stimulated by alcohol.

Alcohol causes the smaller blood-vessels to become dilated, which effect has an important bearing upon the old false tradition that alcohol warms the body and therefore should be taken when the body is about to be exposed to severe cold. This is a fallacy. As a matter of fact, alcohol lowers the temperature of the body by dilating the blood-vessels just beneath the skin, and so increasing the loss of heat from the skin. At the same time the skin *feels warmer*, and this sensation has given rise to a fallacy that has probably cost

many lives. And not only does alcohol lower the temperature of the body, but it also lessens the power of the body to resist cold, and is therefore totally unsuited for those who are exposed to low temperatures.

Even in small doses alcohol is the reverse of helpful when either muscular or mental work is required. The acuteness of all the senses is quickly diminished by it. Any stimulation produced by alcohol is always followed by a period of depression. In large doses alcohol depresses and paralyses the nervous system, and in still larger quantities it acts as a narcotic poison like opium, producing insensibility and sometimes causing death.

If it is taken in repeated large quantities, the organs tend to become diseased. It increases the tendency to gout and produces diseases of the stomach, liver, kidneys, heart, and nerves—sometimes leading to delirium tremens or insanity. There can be no doubt whatever that a person can do quite as hard or harder work without alcohol than with it. It is a matter of experience that athletes in training, in all climates, can endure more fatigue and strain, and are healthier without alcoholic stimulants than with them. The infinite amount of suffering caused by alcohol is a matter of common knowledge.

For all practical purposes, alcohol has little or no value whatever as a food. Its value, when used by a doctor, depends upon its physiological effects.

The maximum amount of alcohol that may be drunk without producing *obvious* ill effects is two ounces per day. This amount of alcohol is contained in two pints of beer, or half a pint of claret, or four ounces of spirits. Even if this amount is taken, the following conditions should be strictly observed:—

(1) Alcohol should never be drunk between meals—it should be taken only with food.

(2) It should not be taken during working hours, but rather when the day's work is done.

(3) Children should never be allowed to touch alcoholic drinks.

(4) People with insanity or epilepsy in the family should always abstain from the use of alcohol.

PRACTICAL WORK

I. Tea and Tannin.—(*a*) To test for tannin in tea. Take some strong tea in a test-tube. Add a few drops of ferric chloride solution. An inky liquid is formed which shows that tannin is present.

(*b*) Make a solution of tannin in hot water. Also dissolve a small quantity of isinglass in boiling water. Add the tannin

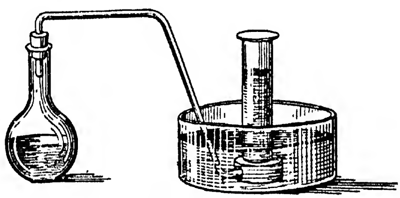

Fig. 49. Apparatus for Fermentation Test.

solution to the isinglass. A white precipitate is produced. The experiment illustrates the action of strong tea on any proteins such as meat.

II. Fermentation.—(*a*) Fit up the apparatus shown in Fig. 49. Put in the flask some sugar and water, and add some brewers' yeast. Leave it in a warm place for several hours. A clear colourless gas collects in the gas jar. Remove the jar when filled with gas, add some lime-water and shake it up. The lime-water is turned milky, showing that the gas is carbon dioxide. For small quantities of gas a test-tube may be used for the collection instead of a gas jar.

(*b*) Next proceed to distil the fermented liquid. Filter the contents of the flask, and pour the clear liquid into a flask

fitted with a condenser as in Fig. 50. Heat the contents of the flask. This causes vapour to be driven off which condenses in the cooled tube and collects as a liquid in the lower flask. When about a teaspoonful of liquid has collected in the cooled receiver, pour it into a watch glass and apply a light. The liquid burns with a pale flame, showing that alcohol has been formed.

(*c*) Repeat experiment (*b*), using some ordinary beer for distillation. In order to prevent excessive frothing the beer

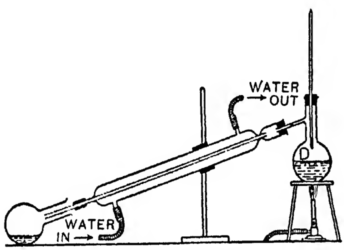

Fig. 50. DISTILLATION APPARATUS.

should be poured rapidly from one vessel to another for a few minutes.

(*d*) Mix a tiny fragment of yeast with a drop of water on a microscope slide. Examine it with the low and also the high power of the microscope.

(*e*) Find the specific gravity of spirits of wine. This liquid usually contains 84 parts of alcohol with 16 parts of water. Notice its absence of colour, its burning taste, its characteristic smell, its neutral effect on litmus, and its volatility and inflammability.

CHAPTER XI

EXCRETION

1. Removal of Waste Products

We have seen that the blood receives various nutrient principles from the intestines. It hands over this nourishment to the different organs, to be used in growth, repair, and heat and energy production. From the air in the lungs the blood receives a supply of oxygen which is used up all over the body in oxidising the foods which have been taken. As a result of these oxidation (heat and energy producing) processes, various waste products (water, carbon dioxide, urea, etc.) are formed, and these are poured into the blood again.

The blood, therefore, not only brings up the foods from the digestive organs and the oxygen from the lungs, but it takes away the waste products that are formed in all parts of the body. To prevent these injurious waste products from accumulating in the blood, some organs have been given the work of getting rid of them. For example, we have seen that the lungs get rid of carbon dioxide, water, and a small quantity of organic impurities. The other organs which help to remove the waste matters from the blood are the **kidneys** and the **skin**: the former are dealt with in the sections which follow, and the latter in Chapter XII.

2. The Kidneys

The kidneys are two in number, and are situated in the loins, one on each side of the vertebral column. They are of well-known shape, and are dark red organs, about four inches long and two and a half inches across, and each weighs about five ounces. In front they are covered with peritoneum (the common covering of all abdominal organs), the back being attached to the body wall.

They are so placed in the body that the concave edges face each other, the outer edge being convex. The depression at the middle of the concave inner edge is called the **hilus.** At this point the renal artery and the renal vein enter and leave the kidney, the one bringing blood from the aorta, and the other taking away blood to the inferior vena cava. A narrow tube called the **ureter** is also found at the hilus. As it approaches the kidney, the ureter expands like a funnel, this dilated part being called the **pelvis of the kidney.**

Each ureter is about fourteen inches long. It passes down from the kidney to the **bladder** which is situated in front of the bony pelvis. The bladder is a muscular bag lined with mucous membrane, and is partly covered with peritoneum.

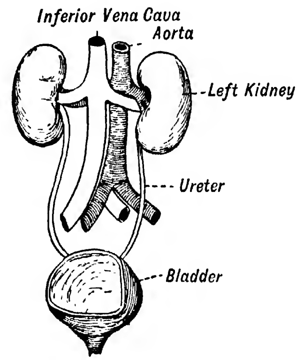

Fig. 51. The Urinary Organs.

The ureters enter in an oblique manner, so that a little flap is formed inside the bladder, and this flap acts as a kind of valve, preventing the urine from passing back up the ureter. The function of the bladder is to store the urine which is constantly trickling into it from the ureters, and to discharge it at intervals. When moderately distended, it will hold a pint.

The substance of the kidney is composed of an enormous number of **tubules** (small tubes) richly supplied with blood-vessels, which form a network all round them. These tubules separate the **urine** from the blood: the essential function of the kidney is the secretion of urine from the blood. The urine then trickles into the pelvis of the kidney, and down the ureter to the bladder.

3. The Urine

Healthy urine is a clear, pale yellow fluid consisting of water in which are dissolved various substances: these are mainly common salt, phosphates, and sulphates of sodium and potassium, and an organic substance called **urea.** About 50 ounces—from two to three pints—of urine are excreted in twenty-four hours. This quantity contains about two ounces of solid matter, one and a quarter ounces of which consists of urea.

The amount of urine passed in a day varies with the temperature. In cold weather more urine is passed than in warm weather. This is because the cold contracts the blood-vessels in the skin, and thereby causes more blood to go to other parts—including the kidneys. The extra supply of blood causes the extra secretion of urine. In warm weather this is reversed. It is only the water that varies; the solids in the urine do not vary much.

PRACTICAL WORK

I. The Kidney.—Take a sheep's kidney. Notice its shape and draw it. Carefully remove the fat from the hilus, and find the artery and vein, which will look rather red; and the ureter, which looks much paler. Cut along the ureter, and follow it until it expands into the pelvis. If you cannot do this, cut open the pelvis, and trace it to the ureter, by cutting it along.

II. Urine.—(*a*) Find the specific gravity of a sample of urine. This is usually 1,020.

(*b*) Test its reaction with litmus. This should be acid.

(*c*) Put some urine into a porcelain dish and evaporate down to dryness. A solid residue is left composed of urea and salts.

(*d*) To some urine in a test-tube add a few drops of nitric acid and a little silver nitrate solution. A white precipitate of silver chloride proves the presence of chlorides.

CHAPTER XII

THE SKIN. CLEANLINESS. PARASITES

1. Uses of the Skin

The uses of the skin may be briefly classified as follows:—

(1) It serves as a protective layer on the surface of the body.

(2) The skin is really one of the **excretory organs** of the body. By means of the sweat glands (Sect. 2) that it contains, it gets rid of about one pint of water in twenty-four hours. Small quantities of other substances are also got rid of in the sweat. The skin, therefore, forms one of the three organs of the body that get rid of water—the other two being the lungs and the kidneys.

(3) By the special arrangement of the nerves in it, the skin serves as an organ of touch.

(4) The sweat glands in the skin have the power of covering the skin with water, which, by its evaporation, causes heat to be lost, and the body is thereby cooled. On the other hand, if the sweat is not secreted so abundantly as to make the skin actually wet, the loss of heat from the body is minimised, although loss by evaporation from the skin is continually going on, even when the skin looks dry.

2. Structure of the Skin

The skin is made up of two layers, an outer layer called the **epidermis**, and an inner layer called the **dermis.**

The epidermis varies greatly in thickness in different parts of the body, being thickest on the soles of the feet, the palms of the hands, and on the back.

The dermis, or true skin, consists of a strong network of connective tissue, which contains blood-vessels, nerves, glands,

and the roots of hairs. The surface of the dermis is thrown up into small conical processes which project into the epidermis. These processes, called **papillae,** are highly developed in those parts where the sense of touch is acute, and so probably they represent that part of the skin which acts as the organ of the sense of touch.

The **glands of the skin** are of two kinds, the **sweat glands,** and the **sebaceous glands.** The sweat glands secrete the sweat, while the sebaceous glands secrete a fatty substance which serves to soften the skin and hair.

On the surface of the epidermis may be seen small openings called **pores.** These are easily visible through a small magnifying glass. The number of pores varies greatly in different parts of the body, there being about 3,000 per square inch on the palms of the hands, and only 600 on the back and legs. They are the openings of the tubes which convey the sweat from the glands to the surface. If one of these tubes is followed downwards, it is found to lead through the epidermis in a spiral or corkscrew fashion, and then to the lower part of the dermis, where it becomes coiled into a kind of knot, forming the sweat gland. Among the coils are numerous blood-vessels. The cells lining the sweat glands secrete the sweat from the blood.

3. Perspiration

Usually the sweat is secreted continually but in small quantities, so that it evaporates from the skin as fast as it reaches the air. This is called **insensible perspiration.** During exertion, or in hot weather, the sweat is poured out in large quantities so that it is visible on the skin, and this action is called **sensible perspiration.** As the water evaporates it absorbs heat from the body, thereby lowering the temperature.

Sweat consists mainly of water with a very small amount of various substances dissolved in it. The dissolved substances are chiefly common salt, some organic bodies, and a little carbon dioxide.

4. Hair

Hairs are formed of horny cells from the epidermis. Each hair lies in a deep pit called the **hair follicle.** The pits are lined with epidermis, which forms a sheath for the root of the hair. At the bottom of the follicle is a papilla covered with cells of epidermis, and by a multiplication of these epidermal cells the hair grows. As the new cells are formed the older ones are thrust outwards and form the shaft of the hair.

5. Nails

Nails are another form of specialised epidermis. They consist of two parts—a root and a body. The root is that part of the nail which is covered by the skin; the body is the external part which ends in the free edge at the end of the finger. A nail grows in much the same way as a hair, *i.e.* by the multiplication of the epidermal cells at its root.

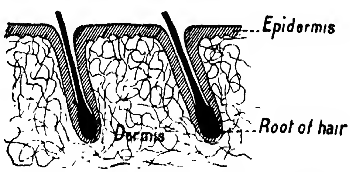

Fig. 52. Section of Skin with Hairs.

6. The Necessity for Cleanliness of the Skin. Baths

The surface of the skin is constantly receiving sweat from the sweat glands, and greasy matter from the sebaceous glands. These keep the skin moist and greasy, causing the dead scales of epidermis to remain sticking to it, and also rendering the skin liable to accumulate dirt, dust, and particles of clothing. If the skin is not regularly cleaned, a layer forms upon it consisting of dried sweat, dirt, scales of dead skin, and grease. This uncleanliness leads to disagreeable results, the chief of which are:—

(1) The sweat glands are obstructed by the dirt. This interferes with their usefulness in getting rid of some of the

waste matters of the body, and throws an extra amount of work on the other organs, *i.e.* the kidneys and the lungs.

(2) The cake of dirt upon the skin lessens the sensibility of the skin.

(3) The cake is a good soil for germs to grow and multiply in; and these may give rise to all kinds of skin diseases.

(4) The dirt may decompose and cause the odour that surrounds dirty people (this smell is also due to dirty clothing).

The use of water alone is not sufficient to remove this greasy dirt, and something must be used that will combine with the grease and make it soluble. Such a substance is soap used with warm water.

Warm water is necessary to clean the skin thoroughly, and a *warm bath* should be taken once a week at least, whether a daily cold bath has been indulged in or not. The face and neck should be washed daily, and the hands should be washed before each meal, especially if the employment is dirty, so as to prevent the possibility of dirty or poisonous particles being eaten with the food.

A *cold bath* every morning is valuable as a tonic, and not for its effect in cleansing the skin. It should only be indulged in by persons of robust health, and then only if it is followed by a sense of warmth and well-being.

An excellent tonic in the summer is *sea bathing*. It should not be indulged in when fasting, nor immediately after a full meal. The best time for sea-bathing is about eleven o'clock in the morning, when the resisting power of the body is probably at its maximum. There is a popular fallacy that the best time to bathe in the sea is before breakfast. As a matter of fact there is no time in the day that for many people could be worse suited for such a performance, but strong, vigorous adults may derive benefit from it. Whenever the dip is taken, it should not be unduly prolonged. From five to ten minutes

is usually sufficient for most people unless the water is obviously warm, but many can remain in for much longer periods without any ill effects. A chilly feeling, with blueness about the fingers and toes, is a sure indication that the bath has lasted too long.

7. Parasites

Human beings are apt to be attacked by various animal parasites, many of which may spread disease. Such conditions are most prevalent in the poorer classes of the community who are without the means or the facilities for proper cleansing, who sleep in overcrowded conditions, and who often find it difficult to change their underclothing. It is also these classes who obviously are unable to afford unlimited soap and warm water, and this fact has led to the common and often misleading assumption that parasitic conditions are due to lack of soap and water or as it is termed "uncleanliness." As a matter of fact it is possible for a person who is scrupulously clean as regards bathing and washing to become troubled with parasites after close, and perhaps only momentary, association with an affected person. To use the word "unclean" when one means "verminous" also leads to confusion, since soap and warm water, the universal remedy for uncleanliness, is not certain to effect any cure of a parasitic condition, or to prevent infection.

The commoner insect parasites are (1) the flea, (2) the bed-bug, (3) the head-louse, and (4) the body-louse.

8. The Flea

This is a flat, wingless insect which can jump several inches from the ground. It lives in clothing and bedding and feeds on the blood of its host. The female flea deposits its eggs on the floor and in crevices, where they hatch out. After undergoing several changes the adult insect develops in about three weeks and it then proceeds to feed on human beings.

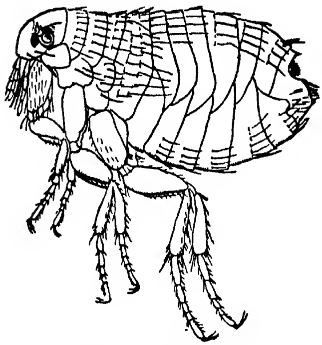

Fig. 53. Human Flea.

The breeding of fleas in a room is prevented by keeping the floor clean and stopping up crevices and crannies thereon. The free use of an emulsion of paraffin and soft soap sprinkled freely over the floor is effective in exterminating the pest. As regards bedding and clothing, constant vigilance and the use of insect powders will soon remove the trouble. Fleas have been proved to be the essential factor in spreading the disease known as *plague*.

9. The Bed-bug

This is a flat, actively running insect with a pronounced odour. It does not live on the body or in the bedding but on the walls and flooring of houses, whence it proceeds to bite and feed on the blood of human beings, generally in the night-time. The eggs are laid in crevices and spaces behind floor or skirting boards or loose wall-paper. The young bed-bug emerges from the egg in a week or so, and is ready to bite a human being at once. The bed-bug is able to pass from one house to the next and may appear unexpectedly in a house inhabited by clean and careful persons, much to their dismay and annoyance.

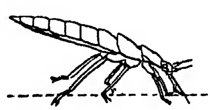

Fig. 54. Bed-Bug Feeding. (Brit. Museum Economic Pamphlet No. 5.)

The presence of bed-bugs is frequently due to a house being

dilapidated and out of repair. In a house which has sound and perfect flooring and walls it is difficult for bugs to obtain lodgment.

To eradicate bugs it is necessary to kill those which are present in the fabric of the room by painting the affected surfaces with crude carbolic acid and repairing the flooring, skirting-boards and walls, stopping up all holes and crevices. To do this one must enlist the help of a practical builder, but it is wise in every case to send to the Town Hall and lodge a complaint with the Medical Officer of Health, who will arrange for the necessary execution of repairs. Vermin are active spreaders of all sorts of disease.

10. The Head-louse

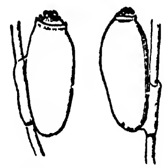

Fig. 55. Eggs of Louse Attached to Hair. (Brit. Museum Economic Pamphlet No. 2.)

This insect lives in the hair and is easily transferred from one individual to another. It bites the scalp in order to feed on blood and in doing so causes irritation and scratching of the head. This irritation may result in inattention to lessons and disturbed sleep at night. The female louse lays her eggs and attaches them to hairs by means of a very hard cement. These eggs are conspicuous and are commonly known as **nits.** The egg hatches out into a young louse in a week, the empty shell remaining attached to the hair.

The prevention of lousiness of the hair depends on its vigilant inspection by the mother and careful combing once or twice a day, which will remove any lice which may have obtained lodgment in the hair. The removal of nits is a more difficult matter and may require the application of warm vinegar. A fine steel comb is also effectively used after application of soft soap and water. Short hair is the best preventive measure against lousiness, and if a girl's hair is worn long it should be plaited, and given constant attention.

11. The Body-louse

This is rather similar to the head-louse in appearance but lives in the seams and folds of clothing, where the eggs or "nits" may be found. The bites cause irritation and scratches are generally visible. The infection is contracted from close contact with the body or clothing of an affected person.

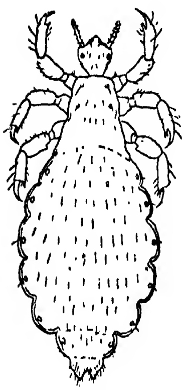

Fig. 56. Body-Louse. (Brit. Museum Economic Pamphlet No. 2.)

To combat the infection it may be necessary for every person in the family to receive a bath whilst the clothing and bedding are at the same time disinfected by the application of steam. Smaller infections are dealt with by ironing all clothing with a hot iron.

12. Ringworm

This includes a group of skin diseases produced by a fungus. It may attack the scalp, beard, or any part of the body. The roots of the hairs are attacked by the fungus, causing the hair to become brittle and break off. Ringworm is very contagious, and is easily spread by means of hats, gloves, towels, hair-brushes, etc. The simplest treatment is the painting of the affected parts with a strong solution of iodine, but a doctor should be consulted. **Favus** is a very bad form of ringworm which attacks the scalp.

CHAPTER XIII

THE NERVOUS SYSTEM. THE EYE. THE EAR

1. The Nervous System

The essential parts of the **nervous system** may be divided into two groups as follows:—

(1) The brain and spinal cord, called the *central nervous system.*

(2) The nerves directly connected with the brain and spinal cord, called the *peripheral nervous system.*

2. The Brain

The cavity of the skull contains a mass of nerve tissue called the **brain,** a large organ consisting of several parts. If it is examined it is found to have on the outside a layer of greyish material called **grey matter** which covers material of a lighter colour called **white matter.** The white matter consists of nerve fibres, each connected with a nerve cell. The grey matter consists of nerve cells which are formed into groups called **centres.** These groups of cells are called centres because certain places on this grey matter have been proved to be associated with special parts, sensations, or acts. In other words, the grey matter is believed to be divided up, as it were, into pigeon-holes or compartments, each having special work to do. Thus special parts of the brain deal with sight, hearing, muscular movements of the face, arm, leg, etc.

The weight of the brain averages about 50 ounces in the adult. Its soft yielding tissue makes it necessary for special means of protection to be provided for the brain and also for the spinal cord. These protections are as follows:—

(1) The general shape of the cranium. This is rounded on the tops and sides, and all corners and angles are conspicuous

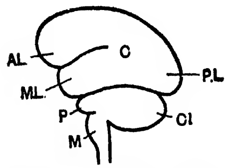

Fig. 57. Diagram of the General Divisions of the Brain (left side).
C = cerebrum; AL = anterior lobe; ML = middle lobe; PL = posterior lobe; P = pons; M = medulla; Cl = cerebellum.

by their absence. The force of a blow directed upon the skull is thus scattered.

(2) The structure of the bones forming the vault of the skull. These consist of two layers or tables. If the outer one be fractured by external violence the inner may escape.

(3) The presence of covering membranes. The outermost membrane, the dura mater, is very strong and tough, and it also sends processes inwards which, being attached to bony projections in the interior of the base of the skull, afford support to different parts of the brain-substance.

(4) The water cushion which surrounds the brain and spinal cord.

(5) The curves of the spinal column and the structure of the column itself (Sect. 4, Chap. I). The presence of the separate vertebrae with their intervertebral discs, and the fact that the spinal column is not a stiff rod, ensure that the brain is protected from shocks and jars while running, jumping, etc.

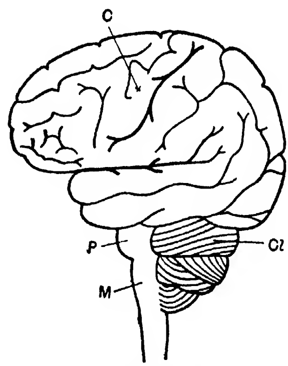

Fig. 58. Diagram of Brain showing Convolutions and Fissures of External Surface on the Side of the Brain.
The line from C leads to the place near which most of the motor areas of the brain are situated.

The brain is divided into four chief parts, (*a*) the **cerebrum,** (*b*) the **pons,** (*c*) the **medulla,** and (*d*) the **cerebellum.** These are shown in Figs. 57 and 58.

3. Functions of the Brain

The higher centres of the mind and intellect are contained in the frontal lobes of the cerebrum.

In the substance of the medulla itself are placed certain important groups of nerve-cells which are the "centres" for

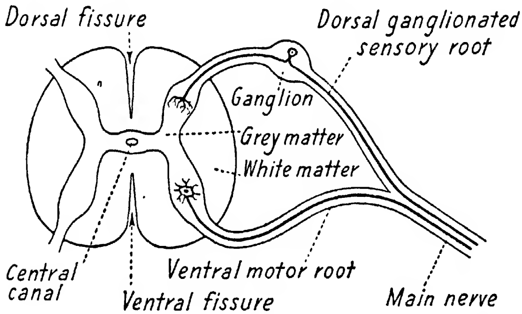

Fig. 59. Diagram of the Spinal Cord, Dorsal and Ventral Nerve-roots, and the Ganglia.
(The thick, black lines represent nerve-fibres.)

controlling the great vital processes of the body, such as the circulation of the blood and respiration. Destruction of the medulla oblongata is instantly fatal, because of the vital centres it contains.

The cerebellum presides over the mechanism of balance or equilibrium. It also regulates, to some extent, the movements of the different muscle-groups throughout the body, particularly those of the lower limbs. Disease of the cerebellum very often causes a peculiar, staggering gait.

The brain receives messages from the organs of sense, and transforms them into sensations such as sight, sound or touch. Thus the eye can do no more than send messages to the brain. If these messages reach that part of the brain dealing with sight, and if that part of the brain is properly developed, is healthy and is educated to interpret these messages, then, and only then, does the individual see. It is the same with the ears and the other organs of sense. The full possession of any one of the senses, therefore, is only possible when the three essential parts and their connections are perfect. These are (1) the sense organ, such as the eye, (2) the connection of this organ with the brain, *i.e.* the sensory nerve—see Sect. 5, and (3) the brain centre, whose special function it is to deal with and properly interpret these messages.

The brain also contains centres, called *motor centres*, concerned with the movements. Such centres are double, one on each side of the brain, and, curiously enough, centres on the right side of the brain govern movements on the left side of the body, and vice versa. Thus, in an ordinary right-handed individual, the arm centre on the left side of the brain would be more frequently used, and would become more highly developed than the corresponding centre on the right side. Such an act as writing would, therefore, have its centre on the left side of the brain.

4. The Spinal Cord

The spinal cord occupies the cavity in the spinal column, and is continuous with the brain above. If it is cut across it is seen to be composed of the same two kinds of tissue as the brain, but the white matter here is arranged outside the grey. The white matter forms the paths of communication with the brain, while the cells of the grey matter can act as "centres" for what are called "reflex actions" (Sect. 6).

The spinal cord gives off a paired series of "spinal nerves." These nerves are numbered according to the vertebra above

them—thus the nerve-pair emerging between the third and fourth lumbar vertebrae is called the third lumbar pair of nerves. An exception is made for the cervical region, because the first spinal nerve emerges between the skull and the atlas; thus there are eight pairs of cervical nerves.

5. The Nerves

Connected with the brain there are twelve pairs of **nerves**, and from the spinal cord there pass thirty-one pairs. Nerves carry impulses either to the central nervous system or from it. If a nerve brings impulses from the skin or from the organs of special sense, such as the eye or the ear, to the brain or spinal cord it is called a **sensory nerve** (afferent or "bringing in"). Those which convey impulses from the central nervous system to the muscles are called **motor nerves** (efferent or "bearing out"). If a nerve contains both sensory fibres and motor fibres it is called a **mixed nerve.** All the spinal nerves are mixed.

Each spinal nerve is formed by two roots—a **dorsal root** and a **ventral root** (back and front). The dorsal root consists entirely of afferent fibres, and is hence also called the sensory root; while the ventral root contains only efferent fibres, and is called the motor root.

There is another difference between the two nerve-roots besides the difference in the direction in which they convey impulses. On the dorsal root there is a swelling called a ganglion; these **spinal ganglia** on the dorsal roots form an important distinction from the ventral roots.

A muscle-fibre or gland-cell may be compared to the charge of explosive in a loaded gun; it contains a store of energy and is capable of doing a definite piece of work, but in order to start it to work, some relatively small amount of work—the pulling of the trigger—must first be done upon it by an external agent. So a muscle (or, at least, a striped muscle) will not work until it receives a *stimulus.* Effective stimuli of various kinds can be artificially applied to muscles,—a

sharp blow on the bare muscle, a drop of acid, or an electric discharge. But under normal circumstances the stimulus is an impulse sent from some nerve-cell along its nerve fibre, which ends in fine branchings over the surface of the muscle-fibre.

What the nature of this propagation of a stimulus may be we do not know. It may, perhaps, be comparable to an electric current or to the firing of a train of gunpowder, if we could imagine only a small portion to be burnt when the train was fired, so that the same train could be fired again and again.

6. Reflex Acts

If the foot of a sleeping person is tickled it is jerked away, and this is spoken of as a **reflex act**, *i.e.* it may take place independently of any control by the will. If the soles of the feet of a man whose spinal cord is injured anywhere above the sacral region be tickled, it often happens that his legs will be suddenly drawn up, although he can neither feel the tickling nor is able, of his own will, to draw up his legs. The explanation is that the sensation is conveyed from the foot along sensory nerve fibres to the spinal cord, the grey matter of which constitutes a " centre " for receiving such messages. These impulses so act upon the grey matter of the cord that they cause new impulses, motor impulses, to travel along the motor nerve fibres to the muscles of the leg and foot, with the result that the foot is jerked away. These movements are produced, to a certain extent, without the action of the will or brain, and take place—imperfectly—when all connection with the brain has been destroyed.

As long as there are the proper connections between the brain and the spinal cord, the brain exercises a controlling effect in limiting the violence of the movements caused by reflex acts. This is called **inhibition.** Also, when conscious, the will, or volition, comes into play, and the brain can limit or prevent the motor impulses being sent in response to a

sensory stimulus. Thus, by an effort of the will, it is possible to prevent the foot being jerked away when the sole is tickled.

For a purely reflex act there are, therefore, five necessary parts: (1) a sensory surface or sense organ, (2) an afferent nerve, (3) a nerve centre, (4) an efferent nerve, and (5) a muscle. Many of the ordinary acts and movements of human beings are reflex acts. Some of them are involuntary or automatic, and take place with or without the will. Some acts that originally required considerable effort and a good

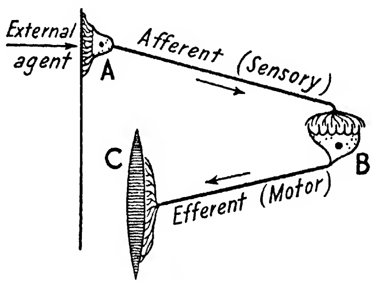

Fig. 60. DIAGRAM OF REFLEX ACTION.
A = Nerve-cell; B = Cell in nerve centre; C = Muscle-fibre.

deal of will control become more or less automatic afterwards. Thus we can go on walking without thinking about it. Among the purely automatic centres which require no stimulus from the outside are those concerned with circulation and respiration. These acts are continually performed during life, but the rate at which the work is done is constantly varied in response to signals sent from parts of the body.

The start that one gives in response to a sudden noise; the jerking away of the hand if it touches a hot body; the closing of the eyes in response to a sudden flash of light; these are common reflex acts. The centres for most of the

reflex acts are situated in the spinal cord. This is proved by the case of a man whose spinal cord is damaged by disease or injury, so that communication with the brain is impossible. In this case—

(1) If the feet are tickled, the legs are sharply drawn up; but:—

(2) The restraining action of the brain being withdrawn, the reflex excitability of the nervous structures is increased, and the responsive movements are more violent.

7. Voluntary Acts

Actions which are controlled by the will acting through the brain are called **voluntary actions**; but even these actions are usually the result of impulses transmitted to the brain through the spinal cord by the nerves. If a person is standing resting his hand on a table and a mischievous boy pricks it with a pin, an impulse is transmitted along the nerves through the spinal cord to the brain, the man becomes conscious (in some inexplicable way) of pain, and efferent impulses may be instantaneously transmitted to various parts, *e.g.* to the muscles of the arm, causing the hand to be snatched away, and to the muscles of the neck, causing the head to turn round to see what caused the sensation.

In the latter case afferent impulses would be transmitted from the eye along the optic nerve, and the man would become conscious of the presence of the boy and the pin. Motor impulses would probably pass from the brain-cells to the muscles of the larynx, tongue and mouth, and he would speak, questioning as to why it was done or warning the boy not to repeat the action, or motor impulses might pass to the muscles of the arm, causing it to strike at the boy.

Thus the object of the nervous system is to enable us to recognise when we are affected by external objects and to respond or act in such a way as will tend to preserve the body from injury.

8. The Eye and the Photographic Camera

The human eye is often likened to a camera, and, as most people have had to do with photography either in the active or the passive sense, the comparison is a convenient one. The essential parts of a camera are a box to give and maintain the necessary shape to the instrument, a convex lens to produce the picture, and a sensitive plate to receive and record it. In

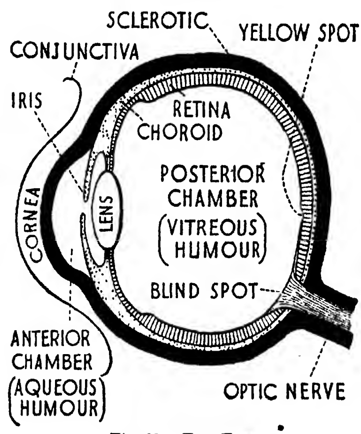

Fig. 61. The Eye.

addition to this the box must be blackened inside to prevent reflection of light, and there must be some mechanism for focusing if pictures of objects at varying distances are to be obtained. The similarity between the eye and the camera will be apparent from the sections which follow.

9. The Coats of the Eye

The eye is nearly spherical in shape, bulging a little in front, and able to turn freely in a bony socket, called the

orbit, which is in front of the skull. The shell or wall of the eye has three layers:—(1) The sclerotic and cornea. (2) The choroid and iris. (3) The retina.

THE SCLEROTIC AND CORNEA.—The **sclerotic** or the white of the eye is a tough, dense, fibrous membrane forming the greater part of the substance of the eyeball. It is the only part of the eye that is capable of resisting any strain, so that if by any chance it stretches or gives way, the rest of the structures will at once follow suit. In front it is continued as the **cornea,** which, being transparent, forms the window of the eye.

THE CHOROID.—The **choroid** is a lining to the sclerotic, and is a network of blood-vessels. Its inner surface is black in order to prevent reflection, which would cause confusion of the images. This layer of black pigment is absent in albinos, who, in consequence are almost blind in bright daylight. Behind the cornea the choroid is represented by a specialised structure called the **iris,** which is circular and contractile. The central hole is called the **pupil.** Varying proportions and distribution of pigment deposited in the iris give the different colours to different eyes.

THE RETINA.—The **retina** forms the inner coat of the eye, and represents the sensitive plate of a camera. It is extremely delicate and thin, averaging only about $\frac{1}{80}$ inch in thickness. It has a complicated structure, being made up of a vast number of minute bodies, placed together side by side like the squares of a mosaic, and is really an elaborate signalling apparatus for sending signals to the brain referring to the kind of impressions that it is receiving. One spot of the retina, called the **yellow spot,** differs from the remainder in its structure. It is the region of most distinct vision, *i.e.* the spot upon which objects are habitually focused when they must be seen distinctly, as in the case of all special work such as reading, writing or sewing. The enormous number of tiny nerve fibres from all parts of the retina are collected together

at the back into a large trunk or cable called the **optic nerve.** The messages pass along these fibres to the part of the brain that has to deal with them. This part of the brain is best regarded as a kind of central office for receiving and interpreting these multitudes of messages.

10. The Contents of the Eye

The eyeball contains:—(1) The aqueous humour. (2) The crystalline lens. (3) The vitreous humour.

The **aqueous humour** is a watery liquid occupying the chamber between the crystalline lens and the cornea.

The **crystalline lens** is a translucent solid body, composed of soft gelatinous living tissue, situated immediately behind the pupil and partly imbedded in the vitreous humour. It is convex on both sides, but more so behind.

The **vitreous humour** is a jelly-like material lying at the back of the lens and occupying about four-fifths of the interior of the globe.

The above three substances are transparent and, with the cornea, constitute the refractive media of the eye, which conjointly act as a converging lens, the function of which is to bring the rays of light to a focus upon the retina.

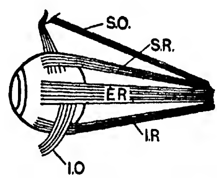

Fig. 62. MUSCLES OF THE EYE.

SO = Superior Oblique;
IO = Inferior Oblique;
SR = Superior Rectus;
IR = Inferior Rectus;
ER = External Rectus.

11. The External Muscles of the Eye

Attached to the outside of the eye are six muscles, four straight and two oblique.

The four straight muscles are attached symmetrically round the globe, above, below, right, left. These muscles, by their contractions, enable us to direct the eye towards different points. It is obvious that by the single action of one, or the combined action of two, the eye can be turned in any direction.

The two oblique muscles are inserted, slantwise, one above and one below the eye. By their contraction they can rotate the eye on its axis. Their action is best understood if a mark in the iris be watched while the head is moved from side to side. It will be then seen that the eye does not rotate with the head, but keeps its vertical meridian constantly vertical, during moderate movements of the head, by the contraction of its oblique muscles.

12. The Internal Muscles of the Eye

The muscles of the iris regulate the *size of the central aperture* (the pupil) and so control the quantity of light which enters the eye; in a dim light the pupil is large, and in a bright light it is small. Other muscles, called **ciliary muscles**, regulate the *curvature of the surface of the lens* so that the rays from any distance are brought to a focus exactly on to the retina; a greater curvature is required for near objects than for distant objects. Both the iris and the ciliary muscles work by reflex actions, of which we are not conscious and over which we have no control.

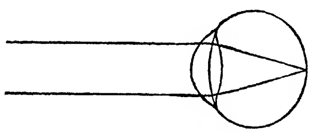

Fig. 63. NORMAL EYE RECEIVING PARALLEL RAYS (FROM DISTANT OBJECTS) AND BRINGING THEM TO A FOCUS ON THE RETINA.

13. Accommodation

Suppose the eye is looking at some object, say a stick. The rays of light coming from any one point on the stick are focused by the lens to a single point on the retina; the rays from some other point on the stick are focused by the lens to some other point on the retina; and so on. In this way a picture or **image** of the stick is thrown on to the retina, and the optic nerve conveys the impression of the picture to the brain. Thus the action of the eye is like that of the

photographic camera, where, by means of a lens or a group of lenses, a picture or image of an object is thrown on to the negative; in both the eye and the camera the image is **inverted**, that is, right becomes left, and top becomes bottom.

If a candle, a convex lens, and a screen are held in line it is easy, by adjusting the distance separating them, to get a clearly defined image of the candle flame upon the screen. The image is then said to be *in focus*. If the candle is moved farther away from, or nearer to, the lens the image on the screen will become indistinct and is out of focus. In the same way it is necessary to adjust, or focus, a telescope or field-glass in order that the desired object may be seen clearly.

Now we know that the normal eye has the power to direct its attention to a distant object and see it clearly, and then immediately to turn its attention to a near object and see that equally clearly. This is called **accommodation**. It is accomplished by altering the convexity of the lens.

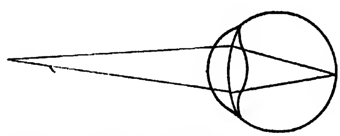

Fig. 64. Normal Eye receiving Rays from Near Object and bringing them to a Focus on the Retina by increasing the Thickness of its Lens (accommodation).

The convexity of the lens is increased by the contraction of a small muscle inside the eye. The more convex the lens the greater the power it has of turning the rays of light out of their original path and causing them to come to a focus. When the eye is looking at distant objects it is receiving light composed of rays that are practically parallel to each other, and the normal lens is capable of bringing these to a focus on the retina. Rays are practically parallel when springing from a point 20 feet or more distant. From near objects, however, the rays are divergent, or spreading, and need more turning to bring them to a focus. In order to focus such rays the convexity of the lens is altered to the necessary extent

by the contraction of the muscle already referred to. So that when looking at distant objects there is no muscular strain, and hence no fatigue, but looking at near objects involves contraction of the muscles, and is liable to bring about strain and fatigue if the exertion is great or the period is unduly prolonged.

When looking at near objects there is necessarily contraction also of the muscles outside the eye in order to pull the eyes towards each other, and so that the axis of each eye is directed towards the object to be seen. It therefore follows that the nearer the object is that we look at the greater is the muscular strain inside the eye, the greater the tension on the sclerotic by the muscles pulling outside, and the greater the pressure exerted by the semi-liquid contents of the eyeball. These strains are likely to distort the shape of the eye. Looking at near objects involves muscular effort and exertion, and if unduly prolonged will cause fatigue, a condition which still further increases the tendency towards distortion.

14. Signs of Eye Defects

All persons who show any of the following signs should at once consult a doctor.

(1) Those with sore eyes (blepharitis).

(2) Those whose eyes are congested and red.

(3) Those who peer and blink when they wish to see anything particularly well.

(4) Those who appear to be in difficulty when they are reading from map or diagram or blackboard.

(5) Those who complain of headache, or who appear to fear a bright light.

(6) Those who turn the head sideways or slanting in order to read.

(7) Those who hold the book nearer than one foot when reading. Also those who hold the book at arm's length.

(8) Those who squint constantly or occasionally.

SORE EYES.—Sore eyelids are often a sign of eye defects. The vision should always be tested and any defect remedied. For amelioration of the condition it is advisable to bathe the eyes every night with a hot solution of boracic acid and smear with boracic ointment. Crusts are best removed by bathing with hot solution of borax.

15. The Ear

The ear is divided into three parts which together make up the *receptive apparatus*, viz.—(1) The external ear. (2) The middle ear. (3) The internal ear.

Further, the eighth cranial nerve—the auditory nerve—

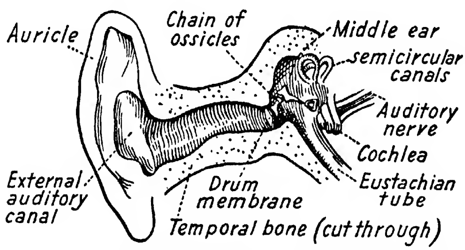

Fig. 65. DIAGRAM SHOWING THE PARTS OF THE EXTERNAL, MIDDLE, AND INTERNAL EAR.

forms the *conducting part* between the ear and the brain, while certain nerve cells in the brain form the *perceptive part*.

The **external ear** is that external structure which is usually described as "the" ear. It serves as a means of collecting waves of sound. An open tube, called the **external auditory canal**, leads inwards from it to the middle ear. The canal is about an inch long, and is set near its mouth with fine hairs, while within, embedded in the walls, lie some small glands, which secrete wax. The hairs help to prevent the entrance of insects. The wax serves to entangle bacteria and insects that have gained admission. If the wax collects in

too great quantity it will block the passage and cause deafness. This can easily be removed by syringing with hot water.

At the inner end of the external auditory canal is the **tympanum** or **ear drum.** This membrane divides the external from the middle ear. It is not set at right angles to the canal, like a door at the end of a passage, but obliquely, so that the floor of the canal (or meatus) is longer than its roof. In appearance and thickness the drum somewhat resembles an oval piece of gold-beaters' skin, or very thin, delicate parchment, or the skin lining an egg-shell. The handle of the **malleus** or hammer-bone, one of the small bones (ossicles) of the middle ear, is attached almost vertically to the inner side of the tympanic membrane.

The drum vibrates in response to sound-waves travelling along the external auditory canal and beating on the drum.

The **middle ear** is a cavity in the temporal bone of the skull. It is separated from the external auditory canal by the ear drum. From the floor of the middle ear there passes downwards a tube (the **Eustachian tube**) which opens into the pharynx. The walls of the middle ear, and the blood in the capillaries there, absorb the air, and would cause a decrease in pressure in the cavity if the Eustachian tube did not admit air, and so equalise the pressure on both sides. If the tube gets blocked, by a severe cold or by the pressure of adenoid growths, for instance, this absorption takes place, the pressure in the middle ear falls, the tympanic membrane becomes tense and is unable to vibrate, and deafness results.

A chain of three little bones, the **auditory ossicles**, runs through the centre of the cavity, joining the outer with the inner walls.

The **internal ear**, or labyrinth, is the most important part of the organ of hearing, and it is also the most complicated. It consists essentially of a membranous bag fitted into a cavity of complicated shape within the substance of the temporal bone.

16. Deafness

Deafness may be due to some comparatively simple cause, such as an accumulation of wax in the external auditory canal, or adenoids blocking up the Eustachian tube; but on the other hand it may be due to more serious and complicated defects, such as diseases of the middle or inner ear, interference with the auditory nerve, or defective development of, or damage to, the hearing centre situated in the brain.

17. Earache

Earache should always receive attention, because it is the first signal that some mischief is being done. In many cases it is due to inflammation in the middle ear. This part of the ear is liable to bacterial invasion along the Eustachian tube. This often happens during scarlet fever. If the inflammation is severe it may lead to the formation of matter or pus in the middle ear. Then the drum is perforated, and the pus trickles down the external auditory canal as "ear discharge." It is of the utmost importance that such a discharge should be medically treated and cured at once. If treated at once the discharge will stop, the hole will probably heal up and the loss of hearing be very slight: if neglected the ear may be permanently damaged or even the brain affected.

PRACTICAL WORK

I. The Human Eye.—(*a*) *Movements of the Iris.*—Place a friend in a chair in front of a window in a good light. Let him keep both eyes open. Note the size of his pupil and then cover over one of his eyes gently with your hand for a few seconds. Take your hand quickly away and notice that the pupil, which had dilated during the temporary darkness, now contracts rapidly as the daylight once more falls upon the eye.

(*b*) *Changes occurring during Accommodation.*—Ask the person to keep looking far away out of the window. Bring a pencil, held vertically, to a point about nine inches away from the middle of his face, telling him to take no notice of it but to

keep on gazing into the distance. Now ask him to look at the pencil, and you will then observe the eye-balls seem to roll slightly inwards towards each other (convergence of the visual axes), and that both pupils contract as he accommodates his eyes to the near object. You cannot, of course, see the changes that take place in the lens.

(*c*) *The Eye and the Camera.*—Using a candle, a convex lens, and paper screen, confirm the statements made on page 139.

II. Demonstration of the Blind Spot.—Make a cross

and a dark circle with ink upon a sheet of notepaper like the above. The cross should be three inches away from the circle. Hold the paper one foot and a half away from the eyes. Close the right eye and fix the gaze of the left steadily upon the circle on the right. Bring up the paper gradually nearer and nearer to your eyes, still looking at the circle with the left eye, and you will find that when the paper has come within a certain distance, generally about five or six inches, from the eyes the cross will suddenly vanish, returning as the paper gets nearer and nearer still to the eyes.

The explanation of this curious phenomenon is that when the cross is at a certain distance from the eye the image of the cross falls upon that point of the left retina where the optic nerve enters the eye-ball, which spot is devoid of the sensitive covering. Hence it is named the **blind spot.** The image reappears when it has travelled beyond this spot and falls upon the sensitive retina.

CHAPTER XIV

PERSONAL HYGIENE. EXERCISE. HABITS

1. Introduction

The judicious combination of **exercise, rest** and **sleep** plays a very important part in the health of the individual. Lack of exercise is soon followed by atrophy, or wasting away of the parts that are not used. A muscle that is not exercised, but lies idle, soon wastes away and becomes useless. This is particularly noticeable in the case of a broken or paralysed limb: the lack of use soon produces wasting and a loss of power of the limb. The brain also, when not exercised by study and reading, does not develop to its fullest possible extent. On the other hand, unless the exercise is combined with the proper amount of rest, the results are even more disastrous, as the body becomes overworked and exhausted.

2. Exercise

Exercise is necessary at all periods of life, but especially so during childhood and early manhood or womanhood. It is the duty of all parents to see that their children enter into the school games, and spend a great deal of time in the open air. On the other hand, it is the duty of teachers to develop school games so as to make physical exercises part of organised play, and to dissociate them entirely from the dreary monotony of the old-fashioned drill. Practically all schools have now adopted physical exercises as part of their curriculum in recognition of the importance of these to the children. In the case of adults the exercise that should be indulged in must depend upon the nature of the daily work. Thus, if a man is doing bodily work all day, his muscles have had quite sufficient exercise, and mental exercise is what he needs for his spare time. On the other hand, those whose occupation

is sedentary, such as clerks, students, etc., need physical exercise in their spare time, in order to bring their muscular, circulatory, and respiratory systems to the proper pitch of development.

For any beneficial result, the exercise taken must be systematic and regular, and not indulged in by fits and starts. By gradually and steadily increasing the work done by them, a set of muscles may be greatly increased in size, but there is a limit to this increase, and if the work be carried to excess the muscles will begin to waste away. Care should be taken to give every muscle of the body its necessary exercise. Many of our sports are faulty in leaving most of the muscles idle. The best real exercise for all the muscles is probably obtained by boxing, lawn tennis and football, in the case of young people, and by walking, swimming or golf with the more elderly. Incidentally, the habit of breathing through the nose, with the mouth completely closed, should be observed always.

Violent exercise should never be taken without proper training. By training is meant the gradual strengthening of the muscles of the body by means of regular and moderate exercises. During violent exercise certain muscles or combinations of muscles may come into action that are but little used, and it is necessary to accustom these gradually to the unwonted exertion. Particularly does this apply to the heart. That organ being in effect a muscular force-pump has to do much more work by way of muscular contraction during violent exercise. Unless the heart has been properly trained beforehand any prolonged exertion becomes dangerous. For this reason a heavy muscular man may be beaten in a race by a thin and puny man whose heart has been properly trained beforehand. When the heart-muscle is beginning to fail one during exertion one is said to "lose one's wind" but a short rest soon revives the heart. Proper training is particularly important for boys and girls who are about to take part in racing or rowing. Unless the heart is properly trained

it may be actually strained or stretched during the strenuous exertion and the foundations of heart disease may be laid.

Some of the physiological effects of exercise deserve special mention. We have already mentioned that the muscles are increased in size and are rendered capable of doing more work. By exercise they are also brought more under the control of the will. The first effect of exercise is, perhaps, the quickening of the heart-beat and the rate of respiration. The heart beats more rapidly and more forcibly, causing an increased flow of blood through the blood-vessels all over the body. If the exercise be sudden and violent, the heart may be incapable of meeting this sudden demand upon it. By gradually increasing the exercise, however, the heart is strengthened and the coats of the arteries are made stronger and healthier.

Respiration is also quickened by exercise. The amount of air taken in at each inspiration is increased, and larger quantities of water and carbon dioxide are given out in the expired air. Thus, a man at rest draws into his lungs each minute about 480 cubic inches of air, but in walking at the rate of three miles per hour he takes in 1550 cubic inches of air, and if he increases his rate to six miles per hour, the amount of air that he inspires is raised to 3250 cubic inches.

The skin acts freely while exercise is being taken. The blood-vessels surrounding the sweat glands are distended with blood, and the secretion of sweat is increased. In this way an extra quantity of waste matter is removed from the body by the skin.

Other effects of exercise include the exhilaration and strengthening of the nervous system, the improvement of the appetite and digestion, and the stimulation of the kidneys and bowels, thereby aiding the elimination of waste matters from the body.

3. Sunlight

The light of the sun whether direct or in the diffused form exercises a beneficial action on the human body. In order

to do this it must fall directly on the skin without the interposition of glass, which cuts off some of the active properties. This is the explanation of the fact that exercise is most beneficial when performed out-of-doors and in the day-time. Exercise performed in-doors is of less benefit, and when carried on in a crowded school-hall with a vitiated atmosphere may be actually harmful.

In order to bring as much of the skin of the body under the influence of sunlight and air the body should be exposed during exercise so far as is consistent with comfort and decency.

Parents should be warned against the danger of excessive or sudden exposure of children to sunlight. Burning by sun's rays is painful and injurious, and may be dangerous. By cautious and gradual exposure for short intervals, the skin's powers of resistance are built up, and great benefit is obtainable. The sudden exposure of children to long spells of sun-bathing at the beginning of a holiday is often the cause of serious illness and damage.

The benefit from open windows is due partly to the admission to the room of sunlight which has not been filtered through glass, as well as to the admission of fresh air. Mechanical systems of ventilation, however perfect, cannot, for this reason, be considered ideal if they lead to closing of windows.

4. Rest

Without proper rest the organs of the body would soon become worn out. The most absolute rest is that obtained by sleep. The amount of sleep required varies with the age and occupation, but, speaking generally, the average adult requires seven or eight hours' sleep a day. Children require more sleep than adults because their bodies are working at a greater rate, and they are more easily exhausted: those under four years should have sixteen hours' sleep a day; from four to twelve years of age they require twelve hours' sleep; from twelve to sixteen ten hours' sleep is necessary.

The sleeping-room should be quiet and well ventilated. Bedsteads should always be used, if possible, as sleeping upon the floor is less healthy on account of the interference with the free circulation of air around and under the sleeper, and also the increased liability to inhale dust or gases from the floor. A hair mattress is very much to be preferred to a feather bed. Infants should not sleep with adults. They should always sleep in a separate bed or cot, which may be easily constructed out of an ordinary clothes-basket or box. If there are two or more beds in a room they should be as far apart as possible.

5. Habits

Either good or bad habits are bound to be formed by children as they grow up, and so it behoves all parents to see that the habits that the children form are those which are conducive to their health and happiness. The habit of eating slowly and chewing the food well, and of having regular meals, has already been referred to. The danger of forming the habit of taking alcoholic drinks has also been mentioned. Smoking by young people is a habit which should also be strongly opposed. Among the necessary and important habits are cleanliness (Chapter XII), attention to the regular action of the bowels, and proper attention to the teeth, mouth and hair.

Some of the habits referred to are dealt with in the sections which follow.

6. Tobacco

In growing girls and boys smoking is injurious and should be strictly prohibited. In the case of the adult it is a luxury and not a necessity, although many people assert that smoking has a beneficial effect on them and enables them to face the stress of life with increased happiness. There is no doubt that smoking in excess is injurious and may occasionally be the cause of disease.

Tobacco smoke should never be inhaled, the harmful effects being much increased by this practice. It is unwise to smoke just before any work requiring physical exertion.

7. Care of the Bowels

The bowels should be freely opened at least once a day. The best way to secure this is to take a proper amount of exercise daily and to cultivate the habit of evacuating the bowels at the same time each day. The most convenient arrangement is to take a short rest after breakfast during which the action should take place. The hands should be washed after completing the toilet.

Constipation has a bad effect on the general health and may lead to more serious ailments. It also diminishes bodily vigour and interferes with the capacity for mental work. If present it should not be treated haphazard by the administration of aperients, but advice should be sought from a doctor. Very often some alteration in the diet will effect an improvement, *e.g.* the addition of whole meal bread, fruit and vegetables, etc.

8. Care of the Mouth and Teeth

The commonest diseases of the mouth are—(1) decay (caries) of the teeth, and (2) inflammation of the gums.

The *predisposing* causes of maladies of the mouth are—(1) uncleanliness, (2) errors in diet, (3) any cause which tends to lower the general vitality and diminish the resisting power of disease. The dental history of the individual is largely decided during early development, before and soon after birth, and is mainly dependent upon nutrition.

The *exciting* causes of maladies of the mouth are—(1) decomposing particles of food, (2) bacteria, (3) deposits of tartar, (4) mechanical causes.

Decay of the teeth is caused by acid decomposition of liquid and solid foods and by acid-forming bacteria. Decay always starts on the outside of a tooth and will spread rapidly

or slowly according to the position of attack and the resisting power of the patient, until it destroys part of the outer substance of the tooth and reaches the large cavity inside, which contains nerves and blood-vessels. In the latter case pain will probably be experienced. When the soft tissues in this cavity die, decomposition sets in, and, in time, an abscess may form at the root of the tooth.

Teeth can be saved even after a late stage has been reached, but it is most desirable that dental advice should be sought long before pain has been felt, so that the chief blood supply, which is in the cavity in the centre of the tooth, may be preserved in a healthy condition. Poisons from the decayed cavities are constantly being swallowed in the saliva and in food, and will in time give rise to digestive disorders.

Mouths in which there are decayed teeth or other unhealthy conditions are a fruitful breeding-ground for bacteria. The germs of many infectious diseases may be in such mouths, and though the individuals with unhealthy mouths may not themselves contract the disease, they can, by spreading germs in droplets (as by talking, coughing or sneezing), infect other people. Such people are then not only a danger to themselves but to those with whom they associate.

Many people, even among those who are educated, consider that the milk teeth are not of much importance, because they will be replaced by others. This is erroneous, as the milk or first teeth are of the very greatest importance; they have to perform mastication for a number of years and, if allowed to decay, the jaw does not develop to its full capacity. In consequence the permanent teeth have not proper space to grow in and become crowded together and irregular. This in its turn predisposes to decay of the permanent teeth.

It is therefore necessary that children should be taught how to keep the teeth and mouth clean, and this service should be done for them until they are old enough to do it for themselves. Without good teeth there cannot be

proper mastication; without proper mastication, digestion is impaired; without digestion, food cannot be assimilated; the result is that nutrition is defective and health suffers.

The saliva or spittle deposits a substance called tartar on the teeth which looks and feels "like stone." Ignorant people think that this tartar is a good thing. Its presence is often due to the habit of not keeping the mouth clean. Deposits of tartar are the chief causes of inflammation of the gums and membranes of the mouth. This inflammation, if neglected, often leads to a serious condition which is painful and exceedingly difficult to cure, and in many cases will cause the loss of perfectly sound teeth. Rheumatism, anaemia, and many conditions of ill-health may be due indirectly to the presence of decayed teeth or inflamed gums.

To avoid teeth troubles—(1) keep the teeth clean, (2) seek dental advice periodically; don't wait until there is pain.

Care should be taken to remove any particles of food which may become lodged between the teeth, but water alone will not do this; it is therefore necessary that teeth should be brushed at least once a day. The best time to clean them is at night before going to bed, the next best time is after the last meal of the day. Although practically useless as a means of preventing decay and deposits of tartar, the cleaning of teeth in the morning before breakfast is a desirable addition to the ritual of mouth cleanliness and health.

The gums should be brushed towards the teeth and on both sides of the teeth. On the outside next the cheeks and lips this can be done with the tooth brush held in a horizontal position, but on the inside next the tongue it is necessary to use the tooth brush vertically, and with the mouth wide open brush the lower gums upwards and the upper gums downwards.

The tooth-brush should be kept clean and allowed to dry after use. Tooth powders should generally be avoided; they frequently do harm. An economical and satisfactory tooth powder is bicarbonate of soda: failing a good tooth-paste,

soap and water and a clean tooth brush give good results. Careful and regular cleansing of the mouth will prevent much pain and ill-health.

There is much to be said for the use of the tooth-pick on hygienic grounds, although the exponents of good manners decry the public use of this implement. If used, a tooth-pick should be of quill or, best of all, soft wood such as a match, pared to a point.

The prevalence of decayed teeth among the children in our schools constitutes a blot upon our civilisation. The incidence and prevalence of decay of the teeth is essentially an affair of nutrition of mother and child.

In order to reduce substantially the incidence of dental disease big changes must be brought about in the diet and habits, and standard of living of pregnant and nursing mothers, as well as infants and children. The consumption of milk, eggs, cheese, animal fat, fish fat and vegetables must be greatly increased. Breast-feeding must be general and prolonged, and every infant and every child should receive regularly some source of " fat-soluble vitamins " such as cod-liver oil. By such means it would be possible to bring about enormous improvements in the teeth of the next generation, and dental decay and pyorrhoea would cease to be the scourge they are at the present time.

9. Care of the Hair

Thorough and vigorous brushing is beneficial to the hair and scalp. This combined with combing will remove any scurf which may be formed on the scalp.

In the case of girls attending school careful inspection of the hair must be made daily for the detection of any parasites. Accidental infection may occur in the case of any girl, however clean and well tended. Washing of the hair should be performed once a week in order to remove dust and grease; but it has little or no effect in removing parasites without other special treatment.

Short hair is beneficial to health as it enables the health-giving sunlight to penetrate to the scalp and back of the neck and ears. It also much diminishes the possibility of infection with ringworm or insect parasites.

Singeing the hair, after cutting it, or at any other time, is useless. The moderate use of a vegetable hair-oil tends to keep the scalp free from dandruff, and certainly does no harm.

Children's hair needs careful attention to detect early signs of parasites or ringworm or other skin disease. In case of any abnormality of the skin a doctor should be at once consulted, as any neglect may lead to permanent baldness and disfigurement.

CHAPTER XV

CLOTHING

1. Body Temperature and Clothing

The value of a material for clothing depends upon its non-conducting properties with regard to heat. By a *good conductor* of heat we mean a substance through which heat rapidly travels. In other words, if one part of a good conductor becomes warm, then the heat will rapidly spread over the whole of it. A bad conductor of heat, or a *non-conductor*, has the opposite properties, so that if one part of a non-conductor becomes heated, the heat spreads very slowly to the other parts. The application of this to clothing is easily understood when we remember that the temperature of the body is always about 98·6° F., while the external temperature rarely exceeds 90° F. in Great Britain.

The temperature of the body is therefore higher than that of the surrounding air, and so the inside of our clothing will be warmer than the outside. Now if the clothing material is a good conductor of heat, the heat will rapidly pass from the inside to the outside, and on the outside it will be lost in warming the air in contact with it. On the other hand, if the material be a non-conductor, the heat will only very slowly pass to the outside and very little will be lost.

As a matter of fact the body loses heat in several ways, the chief of which are:—

(1) By the skin. This is probably about 90 per cent. of the total loss.

(2) By respiration, the expired air being warmer than the inspired air. Moreover, heat is lost by evaporation in the breath, the expired air being saturated with water vapour.

(3) With the excreta.

The first of these, the loss by the skin, is the only one that we can in any way control, and this loss by skin takes place in three ways:—

(1) By conduction, as we have explained above. This loss is very greatly augmented if the clothes are made of a good conducting material.

(2) By radiation of the heat. The result of radiation is best illustrated by the warmth experienced when sitting near a bright fire. In this case the body receives heat which is radiated from the fire. Similarly, the body itself radiates heat.

(3) By evaporation. When the body is heated by exercise the surface of the skin becomes covered with moisture, which evaporates more or less rapidly according to the circumstances. In doing this it absorbs a large amount of heat from the body. It is at these times that the body is liable to take a chill. The absorption of heat by evaporation is well illustrated by pouring a little spirit or ether on the hand, when a feeling of cold is experienced, which is increased by blowing across the liquid. The loss of heat by the skin is greatly influenced by the weather. In hot weather very little heat is lost by conduction or radiation, but a large quantity is lost by evaporation. In cold weather this is reversed.

The chief objects of clothing are:—(*a*) To prevent loss of heat. (*b*) To protect parts of the body that are especially liable to injury, *e.g.* the feet. (*c*) For ornament.

2. Rules with regard to Clothing

The following rules should be observed with regard to clothing:—

(1) IT SHOULD BE LIGHT.—If proper attention is paid to material, there is no need for heavy clothes. In fact, light clothes made of a non-conducting material are much warmer than heavy clothes made of material which conducts heat well.

(2) IT SHOULD BE LOOSE.—Every one knows how cold the hands may be in tight gloves on a cold day. Air is a bad conductor of heat, and fluffy materials which contain much air in their interstices are far warmer than those which are closely woven. In the same way, loosely-fitting clothes are much warmer than those which fit tightly.

Certain parts of the body are peculiarly liable to be constricted by clothing. For instance, the head is often surrounded with a tightly-fitting hat which must press upon the blood-vessels and prevent the proper circulation of blood, thereby increasing the tendency to baldness. The neck is often constricted by a tight collar which interferes with the circulation and gives rise to headache.

In a past generation of women the lower part of the chest and the upper part of the abdomen were habitually constricted by corsets in order to produce the "waist." Happily, fashions have changed, and in these days the clothing of women is, generally speaking, far more hygienic than that of men.

Fig. 66.
FOOT DEFORMED BY POINTED BOOTS. NATURAL FOOT.

The knee is sometimes constricted with garters. The pressure here prevents the return of the blood through the veins, predisposing to varicose veins.

The foot is often distorted by misshapen boots. In a properly made boot the great toe should be in a straight line with the inside of the foot, whereas it is usually bent towards the other toes in order to make the foot come to an unnatural point.

In summing up, we may say that tight clothes possess the following disadvantages:—(*a*) They are less warm than loose clothes. (*b*) They are also less comfortable, and prevent the

free movements of the limbs. (*c*) Any tightness across the chest will interfere with free respiration.

(3) It should be Porous.—If clothing is not porous it will interfere with the evaporation resulting from perspiration. For this reason, waterproof materials should never be worn habitually.

(4) It should be a Bad Conductor.—The reason for this has already been explained.

(5) It should be Properly Distributed.—It is not a good arrangement to pile clothing on the chest and leave the lower part of the back, the hips and thighs lightly clothed. In the case of children the neck should be exposed as a rule, and, if the season permits, the arms and legs should not be shielded from the direct action of the sunlight, which is beneficial. Sudden prolonged exposure to blazing sunshine is dangerous.

(6) The Weight of the Clothing should be mainly borne by the Shoulders.—Some of the weight may, however, be thrown on the hips.

3. Materials for Clothing

The materials used for clothing are of animal and vegetable origin. From the animal world we obtain wool, silk, furs, feathers, leather, etc. The vegetable kingdom provides cotton, linen, hemp, jute and gutta percha. The commonest and most important materials are silk, wool, cotton, linen and artificial silk.

Wool.—The materials made of wool include flannel, cashmere, alpaca and mohair. Wool from the sheep consists of soft, elastic fibres from three to eight inches long. Under the microscope it is seen to be covered with minute overlapping scales. Wool is by far the best and most healthful clothing at our disposal and should always be worn next the skin. It is a very bad conductor of heat, and readily absorbs

perspiration without becoming wet. For this reason, the liability to take a chill after exertion is lessened when woollen clothing is worn.

Wool has two disadvantages. Unless it is carefully prepared it may be rough and irritating to sensitive skins. Also, it is very apt to shrink in washing. To avoid this, all woollen materials should be washed in lukewarm water, in which the soap has been previously dissolved; the tendency to shrink or become hard is increased by the use of washing-soda and by scrubbing or wringing. They should then be rinsed in clean water, folded, passed through a wringing machine, and dried as quickly as possible.

COTTON.—Cotton consists of the fibres surrounding the seeds of the cotton plant. Under the microscope the fibres appear flat, ribbon-like and twisted. These fibres are worked up into calico, velveteen, flannelette and muslin. Cotton is a good conductor of heat, and quickly becomes wet by perspiration. For these reasons it is not an ideal material for clothing, but modern methods of manufacture have vastly increased its usefulness. It has the advantage, moreover, of being fairly durable, and it does not shrink.

Flannelette is a popular material for underclothing, but, as formerly prepared, it was a cause of fatal burning accidents. Most modern varieties are guaranteed to be non-inflammable.

LINEN.—Linen is obtained from the fibres of the flax plant. Under the microscope these fibres appear round and jointed. The smooth surface of linen makes it very useful for collars, etc., but as a clothing material it is poor. It is a better conductor of heat than cotton, and it becomes wet with perspiration more easily.

ARTIFICIAL SILK.—Artificial silk is manufactured from wood, after chemical treatment. It is largely used for women's underclothing and stockings, and has the property of permitting the beneficial rays of sunlight to penetrate to the skin.

Rubber.—The value of rubber is largely due to its impermeability to water. It is used for all kinds of waterproof garments. Such garments need careful ventilation. Rubber material that prevents rain passing through it will also prevent the passage of sweat, and the inside, therefore, soon becomes damp.

For the soles of shoes thick rubber is excellent, but there should be a layer of porous material between the foot and the rubber sole. In very wet weather the popular rubber Wellington boots are a boon to children, but they should not be worn for long periods. In school they should be changed for slippers, and special measures should be taken to keep the inside dry. Otherwise, continual dampness from sweat will result.

4. Relative Value of Materials

For protection against cold the colour of the clothing counts nothing, and the material with which the clothing is made counts everything. The order of merit of the three commonest materials is (1) wool, (2) cotton and (3) linen. White flannel is just as warm as red for underclothing, in spite of the old-time fallacy to the contrary.

For protection against heat, colour counts almost everything and material very little. The best colour for protection against heat is white. Then comes grey, and then yellow, pink, blue, and last of all, black.

5. Amount of Clothing

The amount of clothing required varies according to (1) health, (2) climate, (3) age.

With regard to health, it is a general rule that sick and feeble people require to be more warmly clad than those in robust health. The variation of clothing with climate is obvious, but it should be noted that in a variable climate such as we have in Great Britain, particular caution should be exercised with regard to clothing.

There could not be a more serious error than the common idea of "hardening" children by *insufficiently* clothing them. It should be remembered that the warmer the clothing the less the amount of food required, as the greater part of our food is used in keeping up the bodily warmth. Children require warmer clothes than adults for the following reasons:—

(1) The circulation of the blood in a child is quicker than in an adult. This causes greater loss of heat by bringing more warmth from the inner parts to the surface.

(2) The amount of surface compared with the bulk of the body is greater in a child than in an adult, and so there is relatively a larger area from which heat is lost.

(3) A certain proportion of the child's food must be devoted to growing purposes and building up the body. Warm clothes check the loss of heat from the skin, thereby causing less of the food to be used in producing heat, and leaving more to be used for growing.

On the other hand, exposure to sun and air keeps the skin healthy and maintains in working order its mechanical control of the loss of heat from the body.

With old people the circulation is feeble, and their power of heat production is small. It is therefore important that they should be warmly clothed, and the extremities especially protected.

6. The Importance of Exposure to Sunlight

Sunlight, whether direct or diffused, has a beneficial action on the human body through its action on the skin. Use should be made of this fact in arranging clothing on the body. *So far as compatible with the prevailing temperature,* children should be clothed habitually in such a way as to expose as much skin surface as possible, *whilst conserving the heat of the body.* In the case of men, such a practice is difficult, since fashion dictates that men should wear collars, long sleeves and trousers. The modern dress of girls and

women, with low necks, bared arms and short skirts is very beneficial to health.

Among school children serious overclothing is common, especially during games and other physical activities. On these occasions superfluous clothes prevent full benefit being received. The occasional tendency of women's fashions towards unnecessarily long skirts for ordinary wear is to be regretted, and this unfortunate reaction from the sensible short skirt is not compensated, from a health aspect, by the use of extremely short shorts for tennis and cycling and other exercises.

The increase in the habit of wearing short sleeves, open necks and brighter colours among boys and men is an encouraging development and represents a great advance.

Reference has already been made to the dangers of excessive and sudden exposures of the body to bright sunlight. This applies to adults as well as to children.

CHAPTER XVI

ACCIDENTS AND EMERGENCIES

1. Introductory

The official textbook of the St. John Ambulance Association points out that " First-aid to the injured is a special branch of practical medicine and surgery by a knowledge of which trained persons are enabled to afford skilled assistance in case of accident and sudden illness." " The duty of the ambulance pupil ends where the doctor's begins, and there ought to be no overlapping or clashing of duty or interests." " Throughout his work the First-aid student must on no account take upon himself the duties and responsibilities of a doctor."

Any moment an accident may occur, or an emergency arise, endangering life and limb. In many cases, immediate measures are necessary, but a doctor can rarely be found at once. Fortunately, an intelligent bystander may often be of great service until the medical man arrives. This immediate treatment should be well known by everybody.

In all cases a doctor should be sent for at once, and the message should state precisely the nature of the accident. It will often save much time if the doctor knows what kind of case he is being called to.

In the sections which follow the subject is dealt with in the following order:—(1) Wounds and bleeding. (2) Fractures. (3) Drowning. (4) Suffocation and choking. (5) Burns and scalds. (6) Unconsciousness. (7) Bites of animals and snakes. (8) Poisoning.

2. Small Wounds or Cuts

In an ordinary small cut the bleeding is not usually extensive, and soon stops. If the cut, and the skin round

it, are perfectly clean, the best treatment is to adjust the edges carefully, paint with tincture of iodine, or wash with a reliable disinfectant soap, such as soap containing 2 per cent. of iodide of mercury. Then place over it a strip of *clean* linen, and bind up the part with *clean* rags or bandage. Do not bandage too tightly. If the wound is at all dirty it must be washed carefully with clean, warm water and disinfectant soap. Do not use sponges or soiled rags for this; everything that touches a wound must be scrupulously clean. Above all things, **do not use cobwebs**, or any other dirty abominations.

Fig. 67. METHOD OF COMPRESSING ARTERY IN THIGH.

Bleeding takes place when a blood-vessel is wounded, and the three kinds of blood-vessels give rise to three distinct kinds of bleeding:—(1) capillary bleeding, (2) arterial bleeding, and (3) venous bleeding.

3. Capillary Bleeding

Capillary bleeding is the commonest and simplest form of haemorrhage. The blood oozes slowly from the raw surface, and appears at many points. This bleeding is easily stopped by painting with tincture of iodine or by tying firmly over the wound a pad of *clean* lint.

4. Arterial Bleeding

Arterial bleeding is much more serious, especially if the artery involved is a large one. The blood is of a bright red colour, and is forced out in jets if the artery is large, or in a continuous forcible stream from the smaller arteries. Arterial bleeding is always stopped by *pressure*, which should be first applied *over the wound itself*. To do this, in urgent cases,

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a flat stone may be tied on by means of the handkerchief. If this does not stop the bleeding, pass a stick or a penknife under the handkerchief and twist it round until the pressure is sufficient. A limb cannot be deprived of its blood supply for any length of time without serious risk, so that great care is necessary in the use of a tourniquet, which is only a temporary or emergency measure. *It should only be applied by a trained person, and requires close, skilled supervision when in use.*

Arterial bleeding from the palm of the hand may be stopped by pressing a pad upon the wound and tightly binding the fingers over it. Similarly, if from the forearm, place a pad in the fold of the elbow, bend the forearm upon it, and tie it tightly to the arm. If from the arm, press a large pad into the armpit and bind the arm to the side. In the same way, bleeding from the foot may be stopped by direct pressure, and binding the leg upon a pad behind the knee will stop much of the bleeding below the knee.

In addition to these special methods, the spots should be learned where the artery may be found and compressed against a bone before it reaches the wound. These points are illustrated by Figs. 67, 68, 69. Bleeding from the head and face can usually be checked by pressure against the bony surface underneath.

5. Venous Bleeding

Venous bleeding is distinguished by the colour of the blood, and the absence of spurting. The blood is purple in colour, and wells up from the wound in a dark, steady stream. To check this, a pad of antiseptic gauze or lint should be firmly bound over the wound, sufficient pressure being employed to stop the bleeding. The limb should be elevated and kept at rest. If the bleeding continues, a tight bandage may be applied round the limb, an inch or so nearer the extremity of the limb than the wound is. In a vein the blood is flowing from the extremity of the limb to the heart.

A most serious form of venous haemorrhage sometimes occurs from ruptured varicose veins in the arm or leg. It requires the following treatment. (1) Lay the patient down. (2) Raise the limb and keep it well raised. (3) Expose the wound fully. (4) Apply digital pressure. (5) Remove constrictions, *e.g.* garters. (6) Dress with a pad of lint and bandage. (7) Should oozing continue after application of the pad, apply a bandage firmly round the limb both above and below the bleeding point.

6. Bleeding from the Nose

Bleeding from the nose is sometimes difficult to stop and may require expert medical attention. Seat the patient in a chair in the open air or before an open window with the head slightly thrown back. The arms should be raised. Undo all tight clothing; apply a sponge dipped in cold water over the nose and at the back of the neck. Instruct the patient to keep his mouth open and avoid breathing through the nose. Place the feet in hot water.

7. Slight Bleeding

Scratches or any abrasions of the skin, *however slight*, should be regarded seriously, especially in schools, and should be washed promptly and thoroughly with a reliable disinfectant soap.

8. Severe Bleeding

The general treatment may be summed up as follows. (1) Send for a doctor. (2) Apply cold and pressure. (3) Give plenty of fresh air, loosen clothing, etc. (4) **Never give brandy** or any stimulants. A dose of brandy will often start bleeding afresh, after it has once stopped. If the patient faints, it is the best thing that could happen.

If an accident has occurred, first of all try to stop any bleeding that may be going on. When this is done, examine for broken bones, and, if any are found, give them the proper treatment or failing this make the sufferer comfortable.

9. Simple and Compound Fractures

When a bone is broken, the greatest possible care should be taken to prevent any movement of it. Sometimes the force producing the fracture is so great that one of the broken ends of bone gets forced through the flesh and skin to the outside, forming an open wound as well as the fracture; this is called a **compound fracture.** When the skin is not broken the fracture is called a **simple fracture.** Unless means are taken to ensure immobility of the parts involved, a simple fracture may easily be converted into a compound fracture.

A compound fracture is a much more serious matter than a simple one. The wound is liable to invasion by germs from the skin or the air, and these may do serious injury, and even cause death. An additional danger that may arise from the unskilful handling of a simple fracture is the possibility of causing one of the broken ends of bone to tear through a main artery or vein.

10. Signs of Fracture

The signs of fracture, by which it is possible to tell whether a bone is broken, are:—

(1) The limb or the part has lost most of its power of movement.

(2) If a limb is injured, a difference will be noticeable between the injured limb and the sound one. The injured one may be lengthened or shortened, or may lie in an unnatural position.

(3) There is pain and swelling at the place of injury.

(4) If the bone is near the skin, the place of fracture may be felt as a small depression in the bone.

(5) By gently moving the limb below the point of fracture a grating sensation is perceived, where the two rough bony surfaces rub together.

11. General Treatment

When any individual has broken a bone, no movement whatever should be allowed until means have been taken to ensure immobility of the part. If the fracture is a compound one, the wound, *if dirty*, should be washed, if possible, with some clean water, or, better, with a reliable disinfecting soap or lotion. Otherwise, paint with tincture of iodine. Then place a pad of lint or a clean handkerchief over the wound, to prevent the entrance of more air.

12. Broken Collar-bone

A broken collar-bone is a common result of a fall, especially among children. An irregularity will be detected by passing the fingers along the collar-bone. Another sign is the inability of the patient to raise the arm above the shoulder.

Remove the patient's coat and braces. Place a pad, such as a rolled-up handkerchief, in the armpit, and bend the elbow and support limb against the chest. Apply a sling and fix it to the side by means of a broad bandage passed round the arm and chest, outside the sling.

13. Broken Ribs

Broken ribs are also of common occurrence. The patient complains of a sharp pain on drawing his breath, and a grating sensation at each breath may be detected by placing the hand over the spot. A broad bandage should be fastened tightly round the chest to restrict respiratory movements, and this is usually found to give relief.

14. Broken Arms and Hand Bones

In the case of a broken arm-bone temporary splints should be cut, so as to reach from the armpit to the elbow. Roughly pad the splints by wrapping them round with handkerchiefs; and place one from the shoulder to the outside of the elbow, and the other from the armpit to the inside of the elbow. Bandage the splints firmly to the arm, and put the forearm in a sling.

A broken forearm is treated by fastening the arm to an angular splint. To make this, bind two pieces of wood at right angles to each other. Next, bend the arm to a right angle at the elbow, and fasten it to the splint with handkerchiefs; then put the arm in a sling.

Broken bones of the hand or finger are best treated by fastening the whole hand flat against a broad splint, and then putting the arm in a sling.

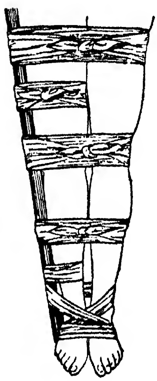

Fig. 70.
SPLINT APPLIED TO BROKEN LEG.

15. Broken Leg

A broken leg is treated in a similar way to the preceding. The splint should reach well up above the knee, and down below the foot. In all injuries to the knee, leg, foot, or ankle, it is a good rule to tie the two legs together, so as to prevent any further injury being done by movement.

16. Sprains and Dislocations

Sprains and dislocations should be treated by a medical man. In the case of a slight sprain the joint may be firmly bandaged, so as to keep it at rest, with a bandage which has been well soaked in cold water. The bandage should be kept wet. Another method is to soak the joint for an hour in water as hot as can be endured, and then to bandage it and keep it at rest for some time.

17. Drowning: The Method of Performing Artificial Respiration

The best and the most modern method of performing artificial respiration for the resuscitation of a person apparently drowned is that devised by Professor E. S. Schäfer, and this has been formally adopted by the Royal Life-Saving Society.

The following instructions are issued by that Society and are incorporated here by permission.

No Waste of Time.—As soon as the body of the apparently drowned person is removed from the water it must be at once placed, belly down, on the nearest flat surface, the head turned a little to one side and the arms laid forwards (Fig. 71). Not an instant is to be lost, even in loosening clothing; artificial respiration must begin without a moment's delay and

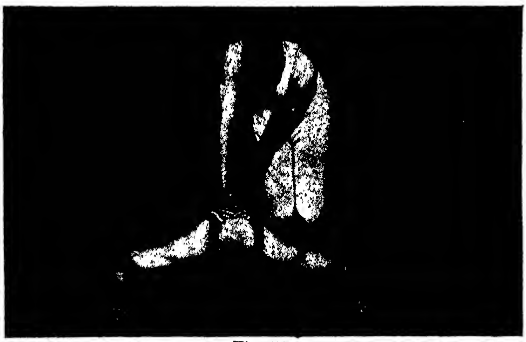

Fig. 71.

be kept up as long as may appear necessary: in some cases life has been restored after an hour or more of unceasing work.

Position of Operator.—To perform artificial respiration place yourself on one side of the patient facing the head, in a full kneeling position, with knees and hips bent. Put your hands on the small of the patient's back, the wrists nearly touching, the thumbs as near each other as possible without strain and the fingers passing over the loins on either side, but not spread out. Then bending your body from the knees and somewhat straightening the hip joints swing slowly

forward so that the weight of your body is conveyed to your hands (Fig. 72).

EXPIRATION.—No exertion is required: the necessary pressure is imparted by the weight of your body. In this way the patient's abdomen is pressed against the ground; the abdominal viscera are forced against the diaphragm; the diaphragm rises and air is driven out of the lungs along with water or mucus which may be present in the air-passages and mouth, and **expiration** is produced.

Fig. 72.

INSPIRATION.—Next, swing your body slowly backwards to its first position, thus removing its weight from the hands (which are left in place) and relaxing the pressure on the abdomen (Fig. 73). The viscera now resume their former position, the diaphragm descends, the thorax is enlarged and air passes into the lungs, **inspiration** being produced. Repeat the movements regularly about 12 times a minute, swinging your body alternately forwards and backwards from the knees.

TIMING.—Every such double movement will occupy about 5 seconds—two of which may be taken up by pressure

(expiration) and three by relaxation (inspiration); to ensure regularity you may count five slowly. Your arms should be kept straight the whole time: not bent at the elbows (Fig. 72). Continue this procedure until there are signs of recovery, shown by the reappearance of natural respirations. If these are ineffective or tend again to cease, artificial respiration must be resumed.

USE OF HELPERS.—While the operator is performing artificial respiration others may, if opportunity offers, endeavour

Fig. 73.

to help restore the circulation by applying warmth in the shape of hot bottles and flannels to the legs and feet. But nothing must be allowed to interfere with the performance of artificial respiration, nor must the patient be turned on his back or receive any restoratives by the mouth, **until his natural breathing is completely re-established and he is fully conscious.** Such change of position may easily block the air-passages and produce fatal asphyxia.

FURTHER TREATMENT.—When the patient is completely restored and his ability to swallow has been tested by a

teaspoonful of warm water, a teaspoonful or two of warm brandy and water may be administered. He may then lie on his side in a warm bed and be encouraged to sleep. But he must be carefully watched for some time to see that breathing does not again fail.

Administration of Adrenaline.—The most efficient remedy in cases of suspended animation is the injection of adrenaline by a doctor directly into the heart. It would be well to do this as soon as possible, but without delaying

Fig. 74.

artificial respiration: if no doctor is present the administration must await his arrival. It must be given without turning the patient on his back except for a moment or two. The injection may be repeated more than once without risk. The effect in restoring the heart is sometimes magical.

The movements of artificial respiration are of the first consequence. If the operator is single-handed, he must attend to these alone until natural breathing is restored. If other assistance is at hand, warm wrung-out flannels, hot bottles, etc., may be applied between the thighs, and to the armpits

and feet; but the movements of artificial respiration must not be interfered with.

After natural breathing is restored, the wet clothing may be removed and a dry covering substituted. This must be done without disturbing the patient, who should be allowed to lie quiet and watched for at least an hour and encouraged to sleep.

18. Suffocation

This may have been produced by hanging. If a body is found hanging, *cut it down at once.* It seems unnecessary to give such obvious advice, but, as a matter of fact, in ninety-nine cases out of a hundred, the individual who makes the discovery runs for the police, thereby wasting valuable time, and losing all chance of saving the life. In such an emergency, cut down the body at once, loosen the rope and all clothing about the neck and chest, and apply artificial respiration without delay.

Suffocation may have been produced by inhaling foul gases, coal gas, or chemical fumes. Remove the body to the fresh air, and apply artificial respiration. When this is successful, give stimulants.

19. Electric Shock

Persons insensible from electric shock are not at all uncommon. They may be discovered still in contact with the electric wire. If this is the case try to switch off the current, or pull out the plug to which the wire is attached, but if this is not possible try to remove the body from the wire. This needs great caution, and the naked hands must never be used. Use rubber gloves if they are at hand. Otherwise wrap a thick dry garment round the hands before you touch the body, or the body may be levered away from the wire by a wooden handled broom, or by a loop of rope.

Then get to work at once with artificial respiration, and persevere with this for at least three hours unceasingly. Most cases will recover. Do not delay for one moment.

Any burns caused by the current should be dusted with dry tannic acid powder or picric acid and covered with antiseptic gauze.

20. Choking

If a solid, such as a lump of sugar, a coin, or a piece of bone, is sticking in the throat, pass the forefinger into the mouth, reach down the throat as far as possible, and try to hook out the foreign body. Sometimes a sudden slap on the back is effectual. With children, the old way of holding them up by the heels is often successful.

When a child has *swallowed* some solid object, a plum stone for instance, give plenty of bread and vegetables for a meal or two. Do not give aperient medicines.

21. Burns and Scalds

First remove any clothing covering the injured part. To do this, use a large pair of scissors, and cut the clothes in such a way that they fall off. Do not pull them at all. If any of the clothing sticks to the skin, leave it there, but cut off the loose parts all round. The burn or scald should then be covered with pieces of linen or cotton, smeared with boracic ointment or soaked in a solution of (one ounce to a pint) bicarbonate of soda in water. Oils and oily dressings are no longer recommended owing to the associated risk of septic poisoning. Modern dressings which are very effective include the preparations of tannic acid or the non-irritating petroleum preparations containing iodine. Next apply a thick layer of cotton-wool or flannel. Keep the patient warm and, if there is much shock, give strong coffee.

A common accident is the catching fire of a woman's or child's clothes. When this happens, the best thing for the woman to do is to throw herself on the floor, and roll rapidly over and over. The duty of a bystander is to wrap round the burning person a rug, carpet, blanket, or coat, and then, laying her on the floor, roll her about until the flames are extinguished.

Children sometimes scald their mouths or throats by drinking out of teapots or kettles. In these cases the scalded parts swell up quickly and suffocation comes on. Send for a doctor at once, as an operation will probably be necessary. While the doctor is coming, wrap the child in a blanket, apply hot flannels to the outside of the throat, and give a little olive or salad oil to drink.

22. Unconsciousness

Unconsciousness may be caused by many conditions, the commonest of which is **fainting.** This is usually caused by temporary feebleness of the heart's action, and is accompanied by paleness of face, and some perspiration. Give the patient fresh air, and put the head as low as possible, either by laying full length on the floor, or by bending the head and body forwards, until the head is below the knees. Apply smelling-salts to the nostrils, or, better, give half a teaspoonful of sal volatile, in water, to drink.

Unconsciousness sometimes accompanies **hysteria.** This is not real insensibility, and may be distinguished by the patient resisting an attempt to raise the upper eyelid; also, when the eyelid is raised, the pupil will not be visible. The best treatment is either to leave the patient entirely alone, or to dash a glass of cold water over the face.

The rupture of a blood-vessel on the brain is the cause of **apoplectic fits** or **strokes.** They are usually accompanied by unconsciousness and a loss of power in one or more limbs. The breathing is usually laboured and noisy. Raise the head slightly and apply cold bandages to it. Put warm flannels to the feet. Keep absolutely quiet, and do not give any stimulants whatever, nor attempt to rouse the patient.

Another common cause of insensibility is **epileptic fits.** The sufferer first screams and then falls down unconscious. The hands are clenched, the legs and arms are jerked to and fro, the face becomes purple, and foam often comes from the

mouth. A common accident at this stage is the biting of the tongue if it happens to get between the teeth. These symptoms gradually subside, and the patient usually falls into a deep sleep.

When an epileptic fit occurs the only thing to be done is to prevent the patient injuring himself. Loosen all clothes about the neck, put something soft under his head, and, if possible, put a piece of wood between the teeth to prevent the tongue being bitten. Do not give stimulants or throw cold water on the face. Allow the patient to go to sleep as soon as possible.

In the case of a child with **infantile convulsions** the best treatment is to put the child into a warm bath while waiting for the medical man to arrive.

A common illness is **insensibility from alcohol** and it is often mistaken for apoplexy, and vice versa. The face is flushed and the breath smells of alcohol. The pulse is feeble but rapid, and the breathing is shallow. Place the patient on his back, and douche the head freely with cold water. Keep the body warm. Give an emetic of two tablespoonfuls of common salt or one tablespoonful of mustard in a tumblerful of lukewarm water, if possible.

23. Bites of Animals: Snake-bite: Stings

Bites of animals should not be regarded as trivial, since they often become inflamed or "poisoned." Within reasonable limits bleeding should be encouraged and the wound should be cleansed with disinfectant soap or antiseptic solution before being dressed.

Abroad, bites of animals have to be treated much more seriously owing to the possibility of the terrible disease known as **hydrophobia** being communicated by the bite. In England the disease is of rare occurrence, and no special precautions are necessary against this disease, unless it is known to have occurred in the locality. Such a fact is not likely to escape universal notice.

There is only one kind of poisonous snake found in England, the viper or adder. Its bite rarely causes death. If the part bitten is a limb, it should be at once tied round with string above the wound. The string must be tied tightly enough to arrest the flow of blood along the veins and to encourage bleeding from congestion.

In the case of stings, if the sting is left in the skin squeeze it out. Then rub the part with a strong solution of washing soda or ammonia or paint with tincture of iodine. An excellent form of treatment is to apply a smear of disinfectant soap, rub up to a lather with a wet finger, and leave the lather to dry on.

24. Poisoning and its Symptoms

Poisoning may be suspected under the following circumstances:—

(1) When an apparently healthy individual is suddenly seized with serious symptoms. Of course, some diseases are sudden in onset, and these must be taken into consideration.

(2) The symptoms appear shortly after taking medicine, or food, or drink. In these cases the poison may have been taken by mistake, or mixed with the food; or it may be the food itself that had the poisonous properties. Handled foods, such as sausages, meat pies, potted meat, have often produced symptoms of poisoning.

(3) If more than one person has partaken of the suspected food, they will probably suffer from similar symptoms.

25. Golden Rules for Poisoning Cases

Certain poisons require special antidotes: for details more advanced books on the subject must be consulted. If you do not know what the poison is, or if you know what the poison is but do not know the special antidote, proceed on the following lines:—

(1) Send for medical help, informing the doctor of the poison suspected.

(2) If the person threatens to go to sleep, by all means keep him awake, but do not make him exhausted. Strong coffee will help.

(3) If there are stains about the mouth, with signs of blistering and destruction of the mucous membrane, do not give an emetic, but give raw eggs, milk, and then oils (linseed oil, olive oil, salad oil).

(4) When there are no stains about the mouth, give an emetic. Make the patient gulp down the emetic rapidly. Repeat in ten minutes if, as often happens, the patient is slow to vomit. Next give raw eggs, milk, and oils. Then give strong tea. Do not give oils if there is a possibility of the poison being phosphorus.

(5) Anticipate and treat for shock by keeping the patient warm.

26. Other Accidents

A common mishap is to damage the fingers by pinching or crushing, for example by a falling window sash, or a banging door. If the skin is not broken a good deal of comfort is obtained by soaking the damaged part in warm water and gradually raising the temperature of the water by the addition of boiling water until a very hot mixture is being endured. Then wrap up the hand in soft bandaging and rest in a sling. If the skin is broken it may be necessary to control haemorrhage. Thoroughly clean with mercuric iodide soap and hot water, wrap up, and keep in a sling.

CHAPTER XVII

SOILS AND SITES. CLIMATES

1. Soils

The health of the locality is influenced by the nature of the soil on which its houses are built. It is often convenient to divide soils into two parts, namely, a deeper portion, called the **sub-soil**, and an upper portion, called the **surface soil.** The sub-soil consists of inorganic materials only, and is the result of the breaking-up of the various rocks by the wearing action of the rain and frost. The surface soil consists of the materials of the sub-soil mixed with organic substances of animal and vegetable origin.

For hygienic purposes it is better to divide soils into two classes according to whether they allow water to pass easily through them or not. Soils that allow water to pass easily through them are called **permeable** or **porous,** while those through which water cannot pass are called **impermeable.** The permeable soils are gravel, sand, sandstone, and chalk; the impermeable soils include clay, limestone, granite, etc.

In most localities it is usual to find a layer of permeable soil of greater or less thickness lying upon an impermeable layer. Water will obviously accumulate on the impermeable layer and form what is known as **ground water.** The pores of the permeable soil above the ground water are filled with air of a special character, called **ground air.** Ground air contains less oxygen and more carbon dioxide than ordinary air, as well as variable quantities of organic impurities. A sudden rise in the level of the ground water will expel the ground air, which will enter a house unless the precaution has been taken to build it on an impervious layer of concrete.

2. The Drainage of the Soil

The ground water may be hundreds of feet below the surface of the soil, or it may be only one or two feet. If it is less than ten feet from the surface it will be necessary to drain the soil before such a site is fit to build upon. For the thorough draining of the soil the following steps should be taken:—

(*a*) Surface drains should be provided to carry off rain as quickly as possible.

(*b*) The natural water courses in the neighbourhood should be cleared out and any obstruction removed.

(*c*) A system of drains with open joints may be laid about ten feet deep, and made to slope towards the nearest water course.

3. Site for a House

There are three chief points to be considered in choosing a site for a house, namely, the soil, the aspect, and the surroundings.

(*a*) Soil.—A permeable soil is usually best. For this reason gravel, chalk, and sandstone make excellent building sites, as a rule. If, however, the permeable layer is thin, and rests upon an impermeable layer such as clay, it is obvious that the upper layer will be continually soaked in the water which cannot get through the impervious layer. Also, a flat site is much more liable to be damp than one which slopes. Marls and clays are impermeable until broken up.

An impermeable soil of a type which allows no water to pass through it, and absorbs none (*e.g.* slate or rock), makes very good building sites.

The depth of the ground water below the surface is a very important consideration. If it is not more than 10 feet from the surface the site is wholly unsuitable without drainage. Striking evidence of the effect upon the health of the district of lowering the level of the ground water is furnished by the town of Salisbury, where the death rate from consumption

was reduced about 50 per cent. by a thorough system of sub-soil drainage.

Peaty soils and reclaimed land at the mouth of rivers are very damp and usually unfit for habitation. Made soils, or artificial sites prepared by filling up large hollows with rubbish of all kinds, always contain a large amount of organic matter which may take years to decompose completely. This kind of soil should not be built upon for several years, and, if it is used after that time, the whole of the ground covered by the buildings should be protected by a layer of concrete.

If a house is built on a damp site, it will certainly be damp unless very great precautions are taken to prevent it being so. To prevent damp rising up the walls it is necessary to lay a course of glazed tiles, slate, sheet lead, or any other impervious material set in cement between the courses of bricks just above the highest point at which the wall is in contact with the earth, and below the level of the floor. Such a layer is called a **damp-proof course.**

(*b*) Aspect.—The aspect should be such as to allow free access of sunlight and air. Light and a free circulation of air are essential to health, and a house, therefore, should not be hemmed in by surrounding buildings or trees. In this country a south or south-westerly aspect is by far the warmest, and so the very best position for a house would be on a slope exposed to the south. The chief windows of the house should face west and south.

Shelter from the cold winds is an important consideration. This may be afforded by neighbouring hills or trees situated at the north or east side.

(*c*) Surroundings.—The neighbourhood of trees, provided they are not too close, is beneficial, as they serve to ward off the cold wind and also assist in drying the soil. The surroundings that are injurious and should be avoided are:—

(i) Decaying vegetable matter such as is met with in marshy districts.

(ii) The immediate vicinity of ponds, lakes, or rivers is to be avoided, especially if they are polluted with sewage.

(iii) Chemical works are undesirable neighbours owing to the noxious gases they evolve.

(iv) The neighbourhood of graveyards may be unhealthy.

(v) Brickfields may also produce injurious gases.

SUMMARY.—We may sum up the most important points with regard to the choice of a site for building as follows:—

(1) The spot should be moderately elevated, sheltered from the north and east, and with a free circulation of air.

(2) The soil should preferably be porous, such as gravel or sand.

(3) The ground water should not be less than 10 feet below the surface of the ground, and it should not be liable to sudden or great fluctuations in level.

(4) There should be no excess of decaying organic matter in the soil such as is found in made soils and soils of a peaty nature. Sewage in soils is obviously injurious.

(5) There should be no injurious surroundings.

4. Climate

By the **climate** of a place we mean the average character of the weather there. Climate is judged by the mean temperature of the air, the direction and force of the prevailing winds, the rainfall, etc. Climate depends upon, and is modified by, the following conditions and circumstances:—

(1) The distance from the equator.
(2) The distance from the sea.
(3) The height above the sea level.
(4) The direction of the prevailing winds.
(5) Presence or absence of vegetation.
(6) Ocean currents and neighbouring mountains.

5. Effect of Distance from the Equator

At the equator the sun's rays fall vertically at noon, and so produce the maximum possible heat. As the distance from the equator is increased the rays fall more obliquely and their heating power becomes diminished.

6. Effect of Distance from the Sea

The land is heated quickly by the sun during the day, but at night it very quickly cools again. The sea, on the other hand, warms and cools very slowly. On a hot day, therefore, the land is at a much higher temperature than the sea, but at night the sea is warmer than the land. The sea has,

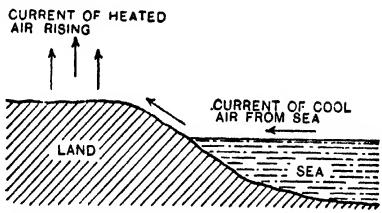

Fig. 75. Production of Sea Breeze During Day.

therefore, a great influence in moderating summer heat and winter cold. Places near the sea have equable climates, with no extreme heat in the summer and no extreme cold in the winter.

We have seen that during the day the land becomes greatly heated while the sea remains comparatively cool. The air over the land will, therefore, be heated and will expand and rise owing to its decreased density. Its place will be taken by a current of cool air from the sea, giving rise to a **sea breeze.** During the night the land rapidly cools, soon becoming cooler than the sea. The air over the sea is now warmer than the air over the land, and so it rises, its place being taken by the cooler air from the land. This is the **land breeze.**

The healthiness of seaside places is mainly due to these breezes. They cause the days to be cooler and the nights warmer than farther inland, besides producing a free circulation of air.

7. Effect of Altitude above the Sea

As a general rule the air becomes colder as the height above the sea is increased. The fall in temperature amounts roughly to about 1° Fahr. for every 300 feet of ascent. The air of the mountains is also more rarefied, and drier and purer than that of the lower regions.

8. Effect of Winds

Winds have a great influence on climate. The action and

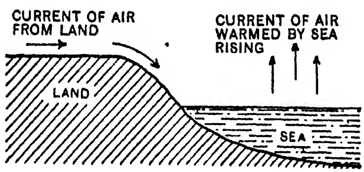

Fig. 76. Production of Land Breeze During Night.

effect of the sea breezes and land breezes at the seaside have already been mentioned. The character of a wind depends upon the nature of the districts over which it has previously passed. For instance, if the wind has just passed over a wide stretch of ocean it will be saturated with water vapour, which will be very liable to condense and produce rain. In England the south and west winds are warm, and very often bring rain, owing to the fact that they are saturated with water vapour and come from a warmer to a colder region. The north and east winds, on the other hand, come from Siberia and Northern Russia and are, therefore, unsaturated and cold.

PRACTICAL WORK

(*a*) Weigh a new, dry red brick. Then immerse it in water for ten minutes. Wipe it dry and weigh again. The gain in weight represents the water absorbed by the brick. Calculate the volume of the brick and the volume of the water it holds.

(*b*) Repeat the experiment with a blue brick.

(*c*) Repeat the experiment with a piece of slate, a glazed tile, and a piece of sheet lead.

CHAPTER XVIII

THE WATER SUPPLY

1. Pure Water

When we talk about pure water from a hygienic point of view, we mean something quite different from the pure water of chemistry. **Hygienically pure water** may have many substances dissolved in it, but they must be present only in very small quantities, and must not have any injurious properties. It must fulfil the following conditions:—

(*a*) It must be quite free from smell. Any smell whatever shows contamination of some sort, and the probability is that such contamination is harmful.

(*b*) It should be colourless, or rather blue when in large quantities.

(*c*) There must be no suspended matters, *i.e.* no deposit should be formed after the water has stood for some time.

(*d*) The taste should be pleasant. Any bitterness or saltness is always suspicious.

(*e*) It should not be very hard (see Sect. 4).

(*f*) It should be well aerated. This is shown by its sparkling appearance.

On the other hand, **chemically pure water** contains nothing whatever dissolved in it. Water in nature is never chemically pure, because of its great solvent properties. Water, as it condenses in the clouds from the gaseous state, *is* absolutely pure, but by the time it reaches the surface of the earth in the form of rain it has acquired additions. It washes various gases and dust out of the air, and reaches the earth as a solution of certain gases, with various solid particles in suspension.

2. Substances in Water

The substances found commonly in water supplied for household use are conveniently referred to as "impurities." This does not mean that they are necessarily dangerous. The impurities in water may be either **suspended impurities** or **dissolved impurities.** Any suspended impurity will usually settle to the bottom if the water is allowed to stand, or it may be removed quickly by filtering. Dissolved impurities are not removed by filtering the water or by allowing it to stand.

The suspended impurities in water may be either of a harmful or harmless nature. (1) The harmless impurities include such substances as fine sand, minute fragments of wood, etc. These do not injure the body by producing disease directly, but they may set up diarrhoea by their mechanical irritation of the intestines. (2) The harmful impurities may be (*a*) disease germs, especially those of cholera and typhoid fever, or (*b*) the eggs of parasitic worms, which, when swallowed, develop in the body.

The dissolved impurities more commonly met with may be classified thus:—(1) Lime Salts, including carbonate of lime and sulphate of lime. (2) Chlorides—chiefly common salt or sodium chloride. (3) Lead Salts. (4) Organic impurities or impurities of animal or vegetable origin.

3. How these Dissolved Impurities get into the Water

(A) THE LIME SALTS.—The sulphate of lime is present in the earth in various localities. It is slightly soluble in water and so, when the water comes in contact with it, it dissolves in just the same way as sugar dissolves in water. The carbonate of lime is, however, quite insoluble in pure water, but it will dissolve freely in water containing the gas called carbon dioxide dissolved in it. Now this gas is always present in the air in small quantities, and as the rain falls through the air it dissolves some of it. When the rain reaches the earth it is really a weak solution of carbon dioxide, and the strength of this solution is increased by the carbon dioxide in the ground

air. It is this solution of carbon dioxide that has the property of dissolving carbonate of lime.

(B) The Chlorides.—Common salt, of course, dissolves easily in water. If it is found in a water supply near to the sea, or to salt deposits, it may be of no importance, but when there is no possibility of such an explanation the presence of common salt points to **sewage contamination**, as sewage always contains large quantities of it. Common salt in a water supply may indicate sewage pollution, just as excess of carbon dioxide in air is an indicator of possible pollution by respiration.

(C) The Lead Salts.—Lead may be dissolved by the water in lead pipes and lead cisterns, or in slate cisterns with red lead joints.

(D) The Organic Impurities.—The sources of these impurities are various:—

(i) Animal or vegetable refuse may have obtained access to the water. Rivers are particularly liable to this kind of pollution.

(ii) The usual source is sewage that has leaked into the water supply. For example, sewage matter may leak into a shallow well, or it may be run direct from a house or village into a neighbouring stream.

(iii) Water from marshes would naturally be very liable to contain considerable quantities of organic impurities.

4. Effect of these Dissolved Impurities

Lime salts cause **hardness** of the water. Hard waters may be defined as those which form a curd or scum with soap. This peculiarity is due to the presence of lime salts, or more rarely of salts of magnesium, dissolved in the water. (See Sect. 5.)

The chloride, common salt, is harmless in itself, but it often indicates a serious pollution due to sewage matter: in this case organic matter would be found.

Lead produces lead poisoning even if there is only one-twentieth of a grain of lead present per gallon of water.

Organic impurities are usually harmless but the sewage from which they are derived may contain germs of typhoid fever or cholera, in which case the water would cause those diseases.

5. Hard and Soft Waters

There are two kinds of hardness, viz. (*a*) **Temporary hardness** which is removed by boiling; this hardness is due to the presence of carbonate of lime. (*b*) **Permanent hardness,** which is unaltered by boiling and is due to sulphate of lime.

The reason why temporary hardness (due to carbonate of lime) is removed by boiling will be easily understood by remembering that this salt is caused to dissolve in the water by means of the carbon dioxide gas which is present. Now when the solution of any gas in water is boiled, the gas is expelled, so that when we boil temporarily hard water the carbon dioxide is expelled, and the carbonate of lime can no longer remain dissolved in the water. It is deposited on the sides of the kettle or boiler as a brown crust. On a large scale the carbon dioxide can be got rid of by adding lime to the water. Lime combines with carbon dioxide in the water, and the carbonate of lime can no longer remain dissolved, so it is thrown out of solution and settles to the bottom as a sediment. This method of softening water in reservoirs by adding lime is known as **Clark's process.**

Hard water is harmless unless the hardness is excessive, when it may cause dyspepsia or diarrhoea, and may increase the tendency to rheumatism. But even when " harmless " it possesses many disadvantages. These are:—

(1) The soap is wasted. Instead of the soap forming a lather, some of it combines with the lime in the water, forming a scum.

(2) This scum is very objectionable, as it clings to the skin or to the clothes that are being washed. It also makes

wash-basins badly soiled every time they are used, thereby increasing unduly the amount of cleaning in the house.

(3) Temporary hardness forms a coat inside the kettle. This makes the kettle thick and a bad conductor of heat. Moreover, in boilers a thick crust is a frequent cause of explosions. If some solid object is kept in the kettle a good deal of the hardness, or lime, is deposited on it instead of the inside of the kettle. An oyster shell is specially suitable as its rough exterior encourages the deposition there.

(4) Hard water is considered to be inferior to soft water for cooking purposes. For making tea, soft water is much better than hard.

6. Sources of Water Supply

The original source of all water supplies is, of course, the rain. The rain that falls on the earth is disposed of in three chief ways:—(1) Part of it evaporates and is carried away in the air, ultimately to fall again as rain. (2) Another part runs along the surface of the ground into the nearest water-course. (3) The third part sinks into the ground and reappears later on as spring water or well water.

The usual sources of water supply include (1) Rain water, (2) Upland surface water, (3) Springs, (4) Wells, (5) Rivers, (6) Lakes.

(1). RAIN WATER.—Rain water is not a direct source of much importance in this country except in country places. It contains no hardness, but dissolves gases from the air, especially carbon dioxide, oxygen, nitrogen, and ammonia, and carries down with it any suspended matters that may be present in the air. In towns, rain water is generally very impure for the following reasons:—(1) The air contains impure gases, soot, etc. (2) It falls on dirty roofs. (3) It is collected in unclean cisterns and water-butts.

When rain water is collected from roofs it is advisable to allow the first portion to run to waste. Rain water is very

liable to dissolve lead, and so it should never be stored in lead cisterns. If it is collected in the open country and in clean vessels it forms a pure and wholesome source of water supply.

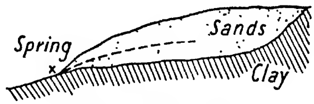

Fig. 77. LAND SPRING.

(2) UPLAND SURFACE WATER.—Upland surface water is water collected from moors and hills. It is very largely used as a source of water supply. The water is collected in natural or artificial lakes, and is brought to the towns by long conduits. It is usually very soft, and is especially useful for general household purposes.

Glasgow is supplied with upland surface water from Loch Katrine. Liverpool, Birmingham, and Sheffield are similarly supplied with upland surface water.

(3) SPRINGS.—Part of the rain water soaks into the ground as we have already pointed out. This water sinks through the upper or pervious layer of soil until it reaches the impervious layer below (a layer of clay, for example). The water cannot get through the layer, and so it runs along the top of it, forming an underground river, called **ground water**. The impervious layer eventually reaches the surface, commonly at the foot of a hill, or in valleys, or in the bed of a river. Obviously, at this point the water will run out of the ground and a spring will be formed.

When the porous layer of soil only consists of a localised patch of gravel or sand the spring is called a **land spring**, and in all probability will dry up during the summer. On the other hand, the porous layer may consist of a range of hills,

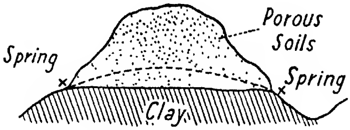

Fig. 78. MAIN SPRING.

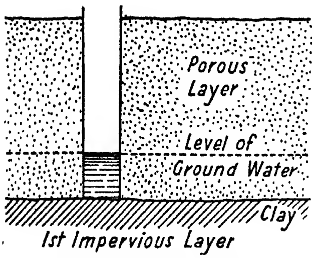

Fig. 79. Shallow Well.

and in this case the spring would be a **main spring**, and would be of a much more permanent character.

The character of spring water will obviously depend upon the nature of the porous layer through which the water has percolated. Sand, for example, would yield a pure water; and water from the chalk would be very hard, but probably a good drinking water in other respects. Spring water is usually well aerated, and is usually a good drinking water.

(4) Wells.—These may be defined as artificial springs. There are two kinds: (1) Surface or shallow wells, (2) Deep wells.

A surface well is one that is dug down to the first impervious layer of soil, *i.e.* one that draws its water from the ground water resting on the first impervious layer. This water has evidently percolated from the surface of the ground around the well and, if there is sewage matter near, this will find its way into the well. This renders shallow wells especially liable to pollution from neighbouring cesspools, middens, or farm yards. The proximity of a cesspool to a shallow well should always arouse suspicion as to the quality of the well

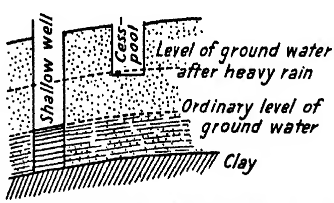

Fig. 80. Fouling of Well Caused by Rise of Ground Water.

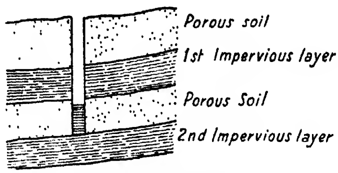

Fig. 81. Deep Well.

water, although some positions may be more dangerous than others (see Fig. 80). A sudden rise in the level of the ground water will sometimes cause sewage matter to be carried direct from a cesspool to the well. The effect of this pollution might be to spread such a disease as typhoid fever if the sewage actually contained such germs which had been evacuated from a person suffering from that disease.

The water from shallow wells is usually well aerated and fairly hard. Shallow wells *may* yield good water provided there is no risk of pollution from the surface or from neighbouring drains or cesspools. To get rid of this danger to some extent we may (1) line the well thoroughly with bricks and cement down to the water line; (2) build a wall about three feet high round the top; (3) pave the ground all round the wall. The only way to get rid of all danger from local pollution is to bore through the first impervious layer, down to the water resting on the second impervious layer, *i.e.* make a deep well.

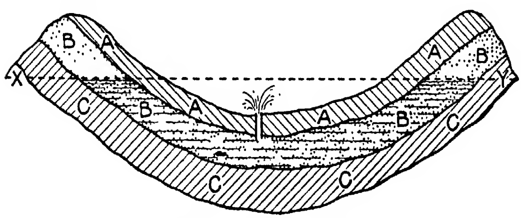

Fig. 82. Artesian Well.
A = Impervious stratum. B = Water-laden chalk. C = Impervious stratum.

A **deep well** is bored through the first impervious layer down to the second, and therefore it taps the water resting on the second impervious layer. By reference to Figs 81, 82 it will be seen that this water must have percolated from the land at some distance, probably many miles from the well.

A special kind of deep well is the **artesian well.** This is a deep well which taps water between two impervious layers, the level of which water (XY) is as high as, or higher than, the level of the ground where the well is sunk. In this case the water will rise like a fountain to the ground level, or even above it.

Deep well water is usually free from organic impurities, but is sometimes very hard, *e.g.* from chalk or limestone districts. In granite, slate, or sandstone districts the water would be very pure. An objection to a deep well water supply for a town is that if additional wells are sunk so as to provide for increased population, only a small increase of water is obtained.

(5) RIVER WATER.—River water usually contains suspended matters, and so particularly needs filtration. It is well aerated and is not so hard as spring or well water. On the other hand, more organic impurity will, as a rule, be found in river water than in spring or well water. If the supply is taken from a river before it reaches houses or cultivated land it is generally pure.

In every case the water from rivers should be filtered. The sewage and other impurities a river receives does not necessarily make the water unfit for drinking a few miles farther on. The reason for this is that rivers possess a **self-purifying action,** by means of which they are enabled to get rid of their impurities. This is strikingly illustrated in the case of the Thames water, which contains no more organic matter at Hampton Court than at Lechlade, 116 miles higher up, although it has received the sewage of several towns on the way. This purification is due to—

(*a*) Oxidation of the impurities by the oxygen dissolved in the water and absorbed from the air.

(*b*) The oxidising and purifying action of certain bacteria in the water.

(*c*) Absorption of the organic impurities by various forms of animal and vegetable life, including fish.

(*d*) The settling of the solid matter to the bottom, carrying with it many micro-organisms.

(*e*) Dilution by the tributaries may occur but considerable purification takes place independently of this.

(6) LAKES.—The water of lakes is generally very pure and soft, with hardly any organic impurities. The waters of Loch Katrine, Bala Lake, and Thirlmere are good examples of the excellent quality obtainable from this source.

7. Water Supply in Towns

Any public service of water is usually too costly for country villages, and so these places depend upon wells for their water supply. In towns, however, a public water supply is necessary. The best source for this is either a large lake, or else upland surface water collected in huge artificial lakes. For storing the water, a reservoir is constructed near the town, and as high as possible. All reservoirs should be capable of holding two or three months' supply.

The amount of water required for each individual per day is usually estimated at a minimum of fifteen gallons. For a good service, *thirty gallons should be allowed for each person per day*. This is made up as follows:—

12 gallons for cooking, washing, drinking, and general domestic use.

8 gallons for flushing drains and sewers, etc.

10 gallons for town and trade uses, public baths, etc.

If a sufficient supply of water is not available the public health tends to suffer. The streets become dusty and water-closets and drains are insufficiently flushed. Private baths have to be restricted and public baths closed down.

8. Distribution of Water in Towns

For distribution to the streets iron pipes called **mains** are used, and are laid from two-and-a-half to four feet underground. They should be protected inside from the action of the water with a coat of preservative material. **Service pipes** run from the mains to the houses. These may be made of lead, wrought iron, or galvanised iron. Lead pipes are usually the most serviceable, but they should be used with caution if the water is such as might act upon lead and dissolve it. Galvanised iron pipes are apt to add traces of zinc to the water.

9. Cisterns

The materials of which cisterns may be made include slate, stone, iron, galvanised iron, lead, and zinc. Slate makes a good cistern, but the junctions are apt to leak, and if these are filled with red lead it is open to the same objections as lead cisterns. Lead should never be used for a cistern for drinking water, because the slightest trace of lead is poisonous. Stone cisterns are not acted upon by water, but they are very heavy, and so are only suitable for underground use. Iron may discolour the water by rusting. Galvanised iron cisterns are generally the most suitable, because they are only slightly acted upon by the water, and these minute traces of zinc are not dangerous.

Cisterns are largely used in houses as a means of supplying water at a low pressure, but unless they are carefully constructed and supervised they may become sources of pollution. They should be covered with a tightly fitting cover and cleaned out occasionally. They should be easy of access for cleaning and so placed that the house is not damaged if a leak occurs. Water-closets should be supplied from a small separate flushing cistern and not directly from a storage cistern used for general purposes. It is always preferable to have a separate supply direct from the main for drinking and cooking.

10. Purification of Water

If the water supply to a house is impure there are two possible methods of purification, viz.:—

(1) By boiling or distillation.

(2) By filtration.

The effects of *boiling* the water are that temporary hardness is removed and disease germs are destroyed. The disadvantage of boiling lies in the fact that the water becomes flat and insipid. If this is objected to, the water may be aerated by allowing it to drip from one vessel to another, or by half filling an ordinary wine bottle with the water and then vigorously shaking so as to cause some air to be absorbed by the water. Boiling is the safest and best method of domestic purification.

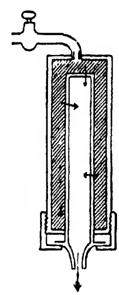

Fig. 83.
PASTEUR-CHAMBERLAND FILTER.

Distillation renders the water absolutely pure, but the water so obtained has the same objectionable feature as boiled water.

In connection with the subject of filtration, it may be mentioned that the only safe *domestic filters* are those such as the Pasteur-Chamberland variety, in which the filtering materials are unglazed earthenware or other fine material which can easily be sterilised. These filters consist of an inner and an outer tube. The outer tube is of ordinary glazed earthenware and is fitted on the tap so that it contains the tap-water at the ordinary pressure. This pressure forces the water through the pores of the inner tube, which is composed of unglazed earthenware. These pores are so fine that even the smallest micro-organisms are unable to pass through. The inner tube can be removed for cleaning when required. The dissolved impurities are not affected by this filter. All filters should be cleaned and sterilised every third day, and the filtering material thoroughly washed and dried.

Purification by a water company on a large scale is effected in one or more of three ways, viz.—

1. **Filtration** through layers of sand and gravel which brings about remarkable purification.

2. **Storage** with exposure to air and sunlight which renders river water very much safer for use as it causes the destruction of disease germs.

3. **Chemical** treatment by liquid chlorine or by a solution of bleaching powder which kills all disease germs and makes the water safe for drinking.

PRACTICAL WORK

I. Evaporation.—Place in separate weighed basins a measured quantity (say 250 cubic centimetres) of (*a*) clear rain-water, (*b*) tap-water, and (*c*) sea-water. Evaporate the water away by placing the basins on a water-bath. When quite dry weigh the basins again. The gain in weight of the basins will give respectively the amount of solids dissolved in rain-water, tap-water, and sea-water.

II. Distillation.—Colour some water with Condy's fluid, place it in a flask and fit the flask with a Liebig condenser, or use a glass retort with a receiver cooled by cold water. Boil the water in the flask, and notice that water begins to drop into the cooled receiver. This is pure distilled water.

III. Hardness of Water.—(*a*) Pass a stream of carbon dioxide (prepared by the action of hydrochloric acid on chalk) through some clear lime-water in a test-tube. Continue passing the gas after the white precipitate of chalk has been produced. The second effect illustrates the action of the carbon dioxide from the air in causing the solution of the limestone or chalk and producing temporarily hard water. The clear liquid now obtained is temporarily hard water. Divide into two parts, (*a*) and (*b*).

(i) Boil.
(ii) Add lime-water. } Carefully note the results in each.

The effect of the boiling or the addition of lime-water is the same, *i.e.* both processes serve to remove carbon dioxide from the water. When the carbon dioxide is removed the chalk can no longer remain in solution, and so a white precipitate of chalk is produced.

(*b*) To 50 c.cm. of distilled water in a 100 c.cm. stoppered bottle add a few drops of "soap solution," and shake. A lather is at once formed.

(*c*) Repeat the above experiment using 25 c.cm. of the clear liquid obtained in the Experiment III. (*a*) above. No lather is formed, but a scum or precipitate is produced. Add more soap solution a little at a time, until a lather is produced after shaking. Note amount of soap solution used.

(*d*) Take another 50 c.cm. of the clear liquid formed in Experiment III. (*a*). Boil it for two minutes, and then filter off the precipitate formed. Now use the clear filtered liquid as in Experiments (*b*) and (*c*) above, and ascertain how much soap solution is required to produce a lather after shaking. The liquid now requires little soap solution to produce a lather, because the hardness (temporary) has been removed by boiling.

(*e*) Use 50 c.cm. solution of calcium sulphate and ascertain the amount of soap solution required to produce a lather. Boil another 50 c.cm. and test again with soap solution. In this case the boiling produces no alteration (permanent hardness).

CHAPTER XIX

HEATING THE DWELLING-HOUSE

1. Transmission of Heat

Heat is transmitted from one part of a body to another, or from one body to another, in three ways. These are (1) conduction, (2) convection, and (3) radiation.

(1) CONDUCTION.—This method of the transfer of heat has already been discussed with regard to the prevention of loss of body heat by clothing. It is the term used when heat passes from one particle of a body to an adjacent particle, just as an article can be passed along a row of people standing in a line.

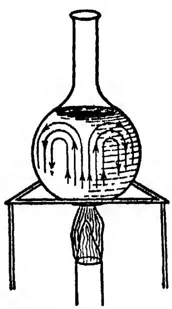

Fig. 84. CONVECTION CURRENTS.

(2) CONVECTION.—The transference of heat by convection is the result of the mobility of the particles of liquids and gases. When matter is heated it, as a rule, expands and, therefore, becomes less dense. Heated gases and liquids are, therefore, lighter bulk for bulk than the cooler parts of the same gas or liquid. The heated parts, therefore, tend to rise, and their place is taken by the cooler parts.

Thus when a flask.of cold water is heated by a Bunsen flame below it the layer of water next the bottom of the flask is heated by means of conduction from the hot glass. The heated part of the water is lighter than the remainder, and so it rises and conveys heat to particles with which it comes in contact. To take its place at the bottom of the flask a stream of colder particles descends. This is termed convection and

the currents of ascending hot particles and descending cooler ones are called convection currents.

(3) Radiation.—Heat also passes from one body to another without warming the intervening space. In this way the heat of the sun reaches the earth, or the warmth of a fire is felt at some distance away. This is termed radiation. Such a transference of heat energy is by means of waves in the ether, similar to the waves which transmit " wireless."

2. Fuel

Fuel includes the combustible substances we use to produce heat. The chief are (1) coal, (2) coke, (3) anthracite, (4) peat, (5) wood, (6) coal gas, (7) oil, (8) artificial fuels.

(1) Coal.—Coal is *mineralised vegetation*, consisting of plants which flourished in remote ages, but have been changed by the action of heat and pressure.

(2) Anthracite.—Anthracite is a hard coal containing a large amount of carbon. It burns without producing smoke.

(3) Coke.—Coke is the residue of coal which has been distilled to obtain coal gas.

(4) Peat.—Peat is a decayed vegetable matter, similar in origin to coal, but it has not been changed so much. It is formed in bogs and marshy places.

(5) Wood.—Wood is obtained from the harder parts of plants.

Each of the above materials consists of substances whose molecules have been built up under the influence of the light and heat of the sun, when the plants were growing. The solar energy is changed into chemical energy. When these substances are burned the complex molecules break down, and relatively simpler molecules are formed. These require less energy to hold their atoms together than the original molecules, and the difference is changed into heat energy.

(6) Coal Gas.—Coal gas is obtained by the distillation of coal in closed retorts. The coal is heated without contact with air, and the products of the destructive distillation are made to pass through condensers in which they are cooled. Coal tar and ammoniacal vapours are thus condensed and collected. The gas is then passed through purifying chambers containing moist slaked lime and other absorbents. These remove gaseous impurities, and the lime also removes carbon dioxide. The gas is then stored in gas-holders or gasometers for use. The coal left in the retort has become converted into coke. *Charcoal* is similarly produced from wood, this being heated to a red heat out of contact with the air.

(7) Oil.—Liquid fuels are obtained from Pennsylvania, Baku, and Iraq. These are supposed to be of organic origin, and derived from the remains of animals or plants.

(8) Briquettes.—Fuel-blocks, or briquettes, consist of fine coal or other combustible material, cemented together by pitch. Sawdust, spent tan, and peat have been used, but have not proved so successful as coal.

3. Methods of Heating

The following methods of heating rooms are in common use:—

(1) By Coal or Coke.—Coal may be used in open fires, in ventilating grates, or in stoves. Coke may be used either alone or mixed with coal in any of these appliances, but is more commonly used in stoves. Incidentally it may be mentioned that the usual method of burning coal at a "low" temperature is wasteful, and the smoke evolved causes atmospheric pollution.

(2) By Coal Gas.—The use of coal gas in open stoves is now common. The best form is where the heat of the gas flame is used to raise the refractory fuel, such as asbestos, to a white heat. Gas is still better used for ventilating stoves,

where the heat is used to raise the temperature of the incoming fresh air. Reflector stoves, where a reflector is placed at the back of a bright flame, or condensing stoves where a condensation of all the products of combustion is supposed to take place, are of little value.

(3) BY OIL.—Oil may be used in ventilating stoves very effectively. It is also often used in the form of a reflector stove.

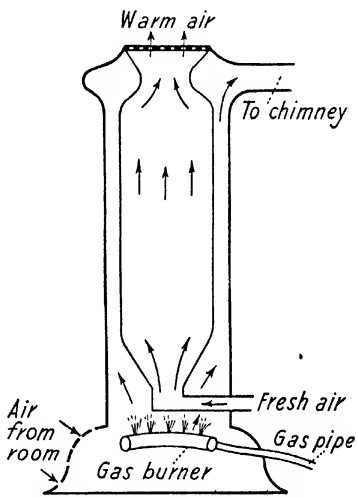

Fig. 85. VENTILATING STOVE (BOND'S).

(4) BY HOT-WATER PIPES.—Hot-water pipes may be arranged either on (*a*) the low pressure system, or (*b*) the high pressure system.

(*a*) In the low pressure system water is heated in a boiler having a pipe leading upwards from the top to various parts of the building, branching as required. The heated water flows along this system of pipes, which finally conducts the water back to the lowest part of the boiler. Heated water rises and the cooler water falls. The pipe entering the boiler is connected with a cistern, which makes good any leakage or waste through evaporation, and the highest point of the pipes is provided with a valve, to allow any air and vapour to escape. The water being under the ordinary pressure of the atmosphere,

and not allowed to boil, its temperature does not exceed 212° F., and the vapour pressure within the pipes is always below that of the atmosphere.

(*b*) In the high pressure system the pipes are arranged to form a complete and closed circuit, which is *not* open to the air, so that the temperature of the contained water may rise above 212° F. A coil of piping is arranged in the furnace, and the pipes connected with this pass through the rooms to be heated and back to the furnace.

(5) By Steam Pipes.—In places where large quantities of waste steam are available, as in factories, it may be economical to heat the building by means of steam pipes. The steam passes along pipes in which it condenses and gives up a large amount of heat, thereby raising the temperature of the pipes. The condensed water runs back to the boiler. The temperature of the pipes can be regulated by valves.

(6) By Heated Air.—The heating and ventilation of many buildings may be economically combined by warming the incoming fresh air. This, on a large scale, is arranged either by passing the air over hot pipes or by arranging for it to pass through a chamber whose walls are partly composed of the hot plates of a stove. On a smaller scale the various ventilating grates and stoves supply fresh, warm air, or radiators may be fixed in connection with the inlet ventilators.

Attempts to provide the whole of the heating by means of the admission of warm air are not entirely successful owing to the fact that the walls of the rooms in such circumstances remain usually colder than the air in the room.

4. Open Grates

The ordinary open grate is the commonest method of heating rooms. It is undoubtedly the most pleasant way, but at the same time it is the most wasteful. The advantages it can claim are that it is bright and cheerful, and forms an efficient and valuable outlet ventilator. On the other hand,

there are the serious objections (1) that it is very wasteful of coal, and gives to the room only about one-eighth of the heat produced during the combustion; (2) that it heats the room unequally; (3) that there is constant care required in replenishing; and (4) that a considerable amount of dust and smoke is produced.

To overcome these objections as far as possible various improvements have been introduced. To decrease the wasteful consumption of fuel and to increase the proportion of heat available for the room, the following alterations have been made to the old-fashioned type:—

(*a*) The rate of combustion of the fuel is decreased by narrowing the opening of the chimney and by cutting off the air from the space under the grate, or in some grates by abolishing the space altogether.

(*b*) The combustion is made as complete as possible, and the radiation of heat into the room is increased by constructing the grate wholly of fire-brick, and by arranging the back of the grate to lean over the fire.

(*c*) The heat of combustion is economised as far as possible by placing the grate in the centre of an inner wall (if the grate is placed on an outer wall some of the heat is used in warming the outside air), and in some cases by building the grate out into the room instead of placing it in a recess.

A considerable economy is effected by using the heat of combustion to warm the fresh air that enters for the purpose of ventilation. The ventilating grate has been devised for this purpose. The fresh air passes through a chamber at the back of the grate, where it is warmed. It then passes up a separate flue and enters the room.

5. Gas Fires

Gas fires are increasing in popularity on account of the ease with which they can be started or discontinued. A properly constructed fire with a flue does not vitiate the air

or produce any abnormal drying effect upon it: it also ventilates. The chief advantages of gas fires are (1) They are clean. (2) They are convenient and save time in lighting. (3) They can be easily regulated. (4) They are more economical than a coal fire, if only required occasionally.

The disadvantage is that they are more expensive for continuous use than coal fires.

6. Stoves

Stoves are not popular in England, but are in common use on the Continent and in America. The more important advantages are (1) They are economical. (2) The rate of combustion can be regulated, and so the heat produced is under control. (3) They are cleaner than open fires. (4) Little attention is required.

The main objections to stoves are briefly:—

(*a*) They are less healthy than open fires. Headaches may be produced on account of the defective ventilation of the room in which the stove is placed.

(*b*) Carbon monoxide may be produced if part of the stove is made of cast-iron. Cast-iron when red hot is permeable to carbon monoxide, which may pass into the room in poisonous quantities.

(*c*) The air of a room heated by stoves tends to become dry and unpleasant. This is usually prevented to some extent by placing a vessel of water on or in front of the stove.

(*d*) The organic particles floating about in the air come in contact with the heated surface of the stove and become charred, thus producing an unpleasant smell.

7. Electric Radiators

These are now largely used and have most of the advantages of gas fires. They do not vitiate the air of rooms and their only disadvantages are that they are expensive and do not ventilate the room in which they are used.

PRACTICAL WORK

I. Conduction.—Obtain pieces of wire made of different metals but of same size. Arrange the wires on a fire-clay tile so that the ends are close together, projecting over the edge of the tile, while the other ends are far apart. Support the tile horizontally by means of a clamp or a tripod, and apply a flame to the ends marked **A** in the diagram. At the end of a minute test the temperature of the distant ends by means of a match. If these ends have become very hot they will ignite a match.

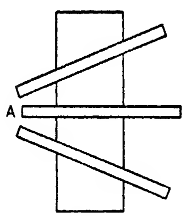

Fig. 86.

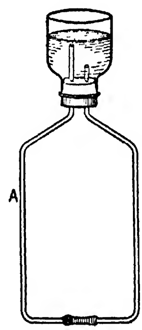

Fig. 87.

II. Convection.—Fill a round-bottomed flask about two-thirds full of water. Add about a teaspoonful of bran. Place the flask on a retort ring or tripod stand and apply a small Bunsen flame to the centre of the bottom of the flask. Note the convection currents set up.

III. Hot-Water Apparatus.—Fit up the apparatus shown in Fig. 87 and fill with water. Then add a few drops of red ink to the water in the top vessel. Apply the flame of a spirit lamp or a small Bunsen flame to the side tube at **A** and note the circulation that takes place.

IV. Convection Compared with Radiation.—Place a thermometer two feet away horizontally from a bright gas flame, and another thermometer two feet above the flame. Note the reading of each. The thermometer above the flame is heated by convection, while the one at the side receives radiant heat only.

V. Radiation.—(*a*) Obtain two bright tin cans and fit each with a cork through which a thermometer passes. Hold one over a flame of burning camphor, turning it round so that the whole surface becomes covered with dull lamp-black. Fill the two cans with water from the tap, replace the corks, and note that the thermometers register the same temperature. Place the two cans at the same distance from a gas or coal fire, or other source of heat, for half an hour, and then note the temperatures recorded by the two thermometers. The blackened vessel will be found to have absorbed more heat than the bright one.

(*b*) Use the same two cans, and put into each an equal quantity of boiling water. Note that the thermometers record the same temperature in each case. Place the two vessels aside in a cool place free from draughts for half an hour, and then read the temperatures. The black can will be found to have lost more heat than the bright one.

These two experiments show that dull surfaces radiate more heat and absorb more heat than bright surfaces.

CHAPTER XX

HOUSE REFUSE. HOUSE-FLIES. RATS

1. House Refuse

In a previous chapter we have seen that the impurities produced in the air by respiration and combustion may be satisfactorily disposed of by ventilation. We now have to discuss the methods of dealing with the solid and liquid refuse of the house. The house refuse may be divided into three parts:—

(1) The excreta, *i.e.* the urine and faeces.

(2) Household refuse, including organic matter, dust, cinders, paper, etc.

(3) Waste water from house cleaning, washing, and cooking.

2. The Excreta

There are two systems of dealing with these waste matters, the **conservancy system** and the **water carriage system.**

The conservancy systems include the use of cesspools, middens, pails, dry-earth, etc. Of these systems we may mention three. (1) In the **midden** system the ashes and the excreta are mixed together and are removed at intervals. (2) The excreta may be kept in **pails** and removed at short intervals. (3) The excreta may be sprinkled with **dry earth** each time the closet is used. This system may be suitable for country houses or small villages, but it is obviously unsuitable for towns of any size on account of the enormous quantities of earth which would have to be dried, transported, and stored.

3. Defects of Conservancy System

All these methods proceed on the evil principle of keeping excremental matters within or near dwellings for more or less

prolonged periods, and, moreover, leave the waste water to be disposed of. This by itself is almost as offensive as if it contained the excreta, and there is no doubt that for towns and large villages the water carriage system of removing the excreta and all waste water together is the best. An abundant water supply is, however, absolutely necessary for the successful working of water-closets.

The dangers to health result in several ways:—

(1) It is impossible to prevent house-flies from settling on human excrement, which has a peculiar attraction for them. Since house-flies are also impartial visitors to all kinds of food, including milk, it may happen that dirt of excremental origin is transferred directly from the closet contents to the food supply by the agency of the house-fly. It is generally agreed that summer diarrhoea of infants is due to contamination of milk in the way described, and this view is confirmed by the fact that summer diarrhoea is more prevalent in towns with conservancy systems, and varies in prevalence throughout the year according to the numbers of house-flies flying about.

Not only summer diarrhoea but typhoid fever, dysentery, and cholera may be spread in the same way. These latter two diseases are now very rare in England, but typhoid fever still remains, and an association between its spread and the conservancy system may possibly exist. It is known that persons recovering from typhoid fever may continue to harbour the germs of the disease in their excreta for months or even for years, and may yet remain perfectly healthy. In such cases the privy contents would be a source of danger to the people of the neighbourhood. It only requires the agency of house-flies to transfer infection from the privy contents to household food. Such food contaminated by infected flies may set up the acute disease in persons consuming it.

(2) Allied to the above is, of course, the *breeding* of house-flies in the privy contents. Such contents being of

animal origin and often warm from decomposition are visited by female flies which deposit their eggs in large numbers. After the hatching of the eggs and after an interval of 10 days upwards, the adult flies emerge from the privy in large numbers.

(3) Another danger arises in country districts from leakage of the contents into the subsoil. This is almost certain to happen unless the privy is most carefully constructed and regularly emptied. In a preceding paragraph it has been explained how the privy contents may become infected with the germs of typhoid fever and other diseases. Should it happen that a shallow well is in the vicinity of such a leaking privy, it is possible that the subsoil water from which the shallow well is supplied may become infected from the privy. The final link in the chain of infection is for a human being to drink the water of the shallow well and become infected with the disease.

(4) A possibility which must not be overlooked is that rats—or even pigs—may feed on the privy contents. As these rats may also visit human food supplies, there is much scope for contamination of such food and even infection in rare instances.

4. Privy or Midden Closets

The old-fashioned plan, still often met with in country places, was to dig a hole in the ground at the back of the closet. This received the excreta for an indefinitely long period.

The more modern midden consists of a comparatively water-tight shallow pit which receives the excreta, on to which are thrown the ashes from the house. It should be at least 6 feet away from any dwelling, and 50 feet away from any spring, well, or stream. Rain must be excluded by a suitable roof, and proper ventilation must be provided. To enable ashes to be readily mixed with the excreta the seat should be hinged. The capacity should be small so that removal of the

contents is frequently necessary. The floor of the privy must be six inches above the ground outside, and should slope towards the door. It should be made impervious by covering with flags or tiles. Means of access for the scavenger should be available without passing through the dwelling, and, lastly, the midden must not be connected with any drain or sewer.

5. Pail or Tub Closets

These are really middens on a small scale. The seat of the closet has a tub or pan placed under it for the reception of the excreta. The pail should be made of galvanised iron with a well-fitting lid, and must be perfectly water-tight, and nearly air-tight when the lid is fitted on for the purpose of removal. At intervals of not more than a week it is removed and a clean one put in its place.

6. Dry Earth Closets

These form undoubtedly the best of the conservancy systems. Faecal matter, with which dry earth has been mixed, becomes not only inoffensive, but after a short time unrecognisable as such. The most suitable soils for this purpose are moderately dry and loose loams, garden soils, dry clay, and brick earth. Sand, gravel, and chalk are unsuitable and inefficient. The method of use is to cover the excreta at once with one and a half pounds of dry earth each time the closet is used. When the pail is full its contents may either be applied at once to the garden or removed to a dry shed where, after frequent turning over and exposure to the air, the earth may be used again as many as eight or ten times.

Automatic closets which apply a measured quantity of dry earth at each use are obtainable. One is shown in Fig. 88. The handle of the closet is connected with a receptacle behind and above the seat, which delivers the regulated quantity into the pail when it is raised.

7. The Water Carriage System—Water-Closets

Water-closets are used to get rid of excreta by means of a flush of water, which carries them along a soil-pipe and drain into a sewer. The requirements of a water-closet are:—

(1) It should be made of hard, smooth, impermeable material.

(2) It should be of a "wash-down" pedestal form, from 12 to 18 inches high, and provided with a hinged seat.

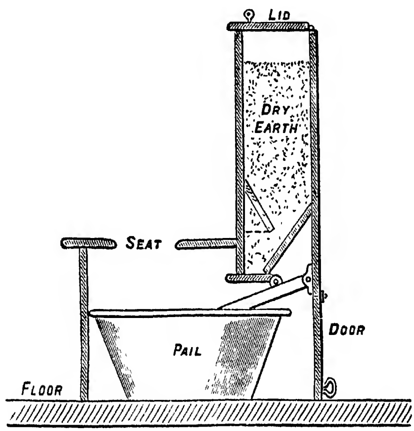

Fig. 88. AUTOMATIC EARTH CLOSET.

(3) It should have a vertical posterior wall, so that the filth falls directly into the water.

(4) It should have a flushing rim and "after flush."

(5) The trap and pan should be made in one piece.

(6) The trap should be of the siphon form.

(7) The water-seal should be $2\frac{1}{2}$ inches.

(8) The flushing cistern should be siphonic, and the overflow pipe should discharge in the open air.

(9) A flush of at least 2 gallons of water must be delivered from a height sufficient to insure a good and effective flush.

(10) The closet must have one external wall with a window 2 feet square, half of which must open. It must be permanently ventilated, preferably by grids.

(11) It should have a proper door and fastenings.

(12) It should not open directly into any room in which people live or work.

Two types of water-closet may be briefly described, viz., the *Wash-out closet* and the *Wash-down closet.*

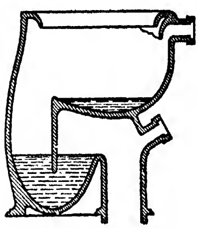

Fig. 89.
WASH-OUT CLOSET.

THE WASH-OUT CLOSET.—This is constructed of stoneware, and has the following features:—(1) The basin and trap are constructed in one piece. (2) The basin is shaped so as to form a shallow container in which the excreta fall.

The flush of water carries it over the ledge and into the siphon-trap below. A layer of water always remains in the basin and this prevents its being fouled by excreta.

The advantages of this type of closet are:—

(1) It is cheap.

(2) It has no mechanical parts to get out of order.

(3) It is open to inspection.

(4) It is not necessary to enclose it in a case.

The disadvantages of this type of closet are:—

(1) The water in the basin is not sufficient to cover the excreta and is apt to splash.

(2) The splashing causes portions of the basin to be fouled in parts out of reach for cleansing.

(3) The basin interrupts the downward flush, so that the water loses the energy gained by the direct fall from the cistern and only partly clears the trap, which may become fouled by deposits on the sides and give rise to bad smells. For effective use this closet needs flushing twice every time it is used.

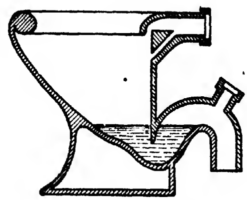

Fig. 90. Wash-down Closet.

The Short Hopper or Wash-down Closet.—This is one of the best water-closets in use, and has superseded the type just described. It possesses all the advantages and none of the disadvantages of the wash-out type. The construction will be apparent from the figure. There should be sufficient water in the basin to prevent the excreta fouling the sides.

8. Flushing Cisterns

To prevent the flushing of closets becoming imperfect through carelessness, many plans have been devised for ensuring that once the flow of water is started it will

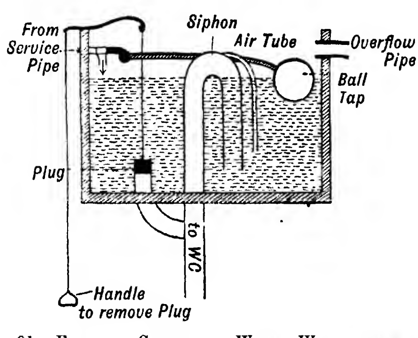

Fig. 91. Flushing Cistern or Water Waste-preventer.

continue until a given volume has been discharged. A good arrangement is shown in Fig. 91. When the plug is removed, water rushes down the pipe and sets the siphon into action; then, even if the plug is replaced, the pressure of the air keeps the water flowing down the siphon until the surface is lowered so much that air is admitted to the short end of the siphon-pipe. A ball-tap is used for automatically

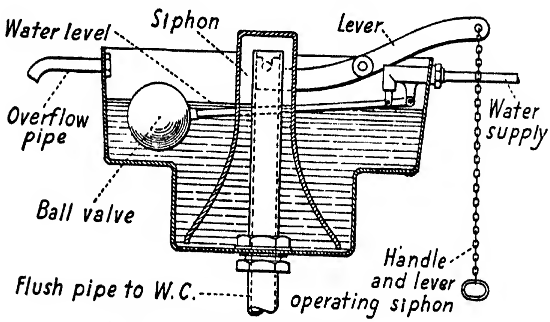

Fig. 92. A Modern Flushing Cistern.

By pulling the chain, the bell-like covering of the flush pipe is raised. When this falls (by releasing the chain) water is forced between it and the flush pipe. This starts siphonage, which continues until the cistern is emptied. As the water level in the cistern falls, the copper ball, or float, sinks with it, and this opens the tap. Water then flows from the tap until the cistern is full again, when the floating ball turns off the tap.

refilling the cistern after discharge. The cistern is usually made of enamelled iron.

The quantity of water required for flushing a closet is two to three gallons, but the regulations of the water companies often limit the capacity of flushing-cisterns to two gallons, with a view to economy. The pipe which carries the water to the W.C. should be not less than 1¼ inches in diameter.

9. The Soil-Pipe

When a water-closet is placed inside the house above the ground-floor a special vertical pipe is necessary in order to carry the excreta from the closet to the drain. Such a pipe is called a **soil-pipe.** It must be constructed in accordance with the following rules:—

(1) It should be entirely outside the house. The best position is against a wall of the house which is not exposed to the rays of the sun.

(2) The best material is drawn lead weighing 7 or 8 lb. per foot, but more commonly cast-iron pipes are used. These should be protected from the action of the water by some effective coating. The joints should be made with lead.

(3) The internal diameter of the pipe should be not less than $3\frac{1}{2}$ inches.

(4) The whole length of the soil-pipe should be as free from bends as possible. Every bend decreases its efficiency as a ventilator.

(5) It must be carried up, full bore, above the eaves of the house and there end with a wire cage top.

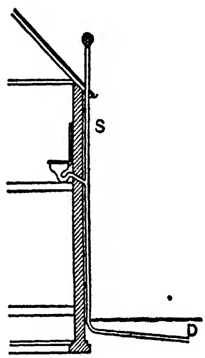

Fig. 93. S = Soil-pipe. D = House drain.

(6) There must be no trap between the soil-pipe and the drain. It is connected direct with the house drain, and is really a continuation of this drain.

10. Trough Closets

A **trough closet** consists of a stoneware trough above which is a series of closets built side by side. At the lower end of the trough its floor turns upwards so that there is always a depth of from one to four inches of water in it. The

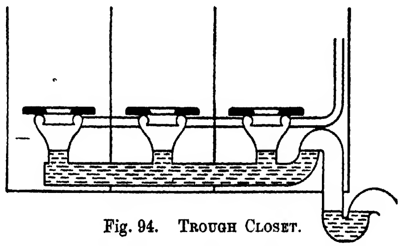

Fig. 94. Trough Closet.

excreta fall into the water. At the upper end of the trough, four or five feet above it, is an automatic flush tank, which should be arranged to flush every six hours at least. The frequency of the flush is arranged by regulating the tap which fills the flush tank.

The only advantage of the trough closet is that it is more or less independent of rough and careless use and it may serve for use in factories.

Trough closets are not suitable for schools. They have a bad educational effect upon children, part of whose education should be the proper use of an ordinary water-closet. It is almost impossible to keep such closets free from objectionable odours.

11. Traps

A **trap** is a contrivance intended to prevent the passage of gases from the sewer into a drain or from a drain or house-pipe into a house. This is usually effected by bending the pipe in such a way as to cause the bent part to remain filled with water. A good trap should fulfil the following conditions:—

(1) It should be made of hard, smooth, and impermeable material and the depth of water making the trap (the water-seal) should be about two inches.

(2) There should be no projections or angles for the deposit of filth, and no movable part.

(3) The flush of water through the trap should completely renew the charge of water in it and cleanse the trap.

(4) The evaporation of water should be checked as far as possible.

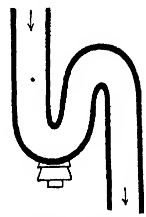

Fig. 95. "S" Trap for Sink.

12. Common Faults in Traps

No traps are perfect, and even the best of them require constant supervision if they are to form an efficient protection. The common faults in traps include the following:—

(1) Liability to unsealing through evaporation of the water, if seldom used.

(2) Liability to unsealing through suction from the soil-pipe or drain unless this is guarded against.

(3) Pressure of gas may force water out. (Ventilation of drain prevents this.)

(4) They always obstruct the flush of water to some extent.

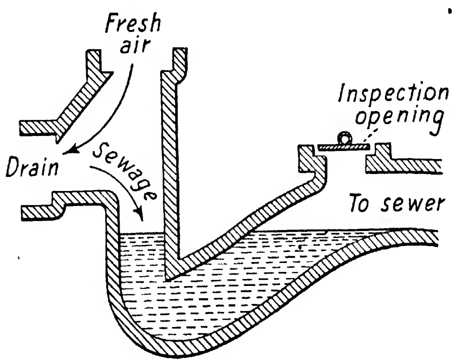

Fig. 96. Buchan's Disconnecting and Ventilating Trap.

(5) Some are filthy and should be discarded altogether if not self-cleansing.

13. The Siphon Trap

The simplest form of the siphon trap is a bend in an ordinary pipe. Water remains in this bend and prevents the passage of gases from one side of it to the other. This form of trap is adapted for various positions, including the following:—

(1) The trap for all forms of modern water-closets.

(2) The trap for lavatory basins and sinks. This trap is made of lead, and is fitted with a plug at the bottom of the bend in order that the bend may be cleaned out if it becomes obstructed.

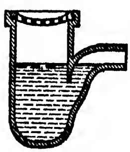

Fig. 97.
GULLY TRAP.

(3) The trap placed near the sewer end of the drain in order to provide for the disconnection of the drain from the sewer. This is usually placed on the sewer side of the manhole or inspection chamber of the drain. The ventilator of the drain serves for the admission of fresh air, which passes along the drain and escapes through the soil-pipe ventilator.

14. The Gully Trap

This is merely a siphon trap modified to receive yard drainage and waste water from sinks and baths. These traps must never be placed inside a house. The waste-pipes from sinks or baths sometimes discharge into the side of the gully below the grating, or on to a sloping surface 18 inches away from the grating.

15. Drains

Every house should be provided with efficient drains to carry waste water to the sewer or to a cesspool. In constructing a drain the following rules should be observed:—

(1) Course.—The drain should not pass under a house if it can be avoided. When a drain passes under a house it must pass direct for the whole distance, and must be embedded in concrete.

When constructing the drain the whole of the trench in which it is to lie should be dug out before any pipes are laid. The floor of the trench should be covered with a layer of concrete four inches thick, on which the pipes rest. The flange of each pipe should be let into the concrete sufficiently to allow the whole length of the pipe to rest upon the surface of the concrete.

The drain should be laid in straight lines as far as possible.

(2) Materials.—Sound, glazed stoneware pipes are generally used, perfectly round in section, with joints made of cement. In certain instances it is necessary to use protected iron pipes. The pipes must be laid so that the sewage flows into the socket end of the pipes.

(3) Size and Fall.—A four-inch drain is usually sufficient. For large establishments a six-inch drain may be necessary. The fall in each case should be as regular and even as possible, the rule being that the smaller the pipe the greater is the fall necessary to make it self-cleansing. Four-inch pipes need a fall of 1 in 40 (*i.e.* a vertical fall of one foot in a length of 40 feet), while six-inch pipes need a fall of 1 in 60.

(4) Junctions and Bends.—All junctions and bends in a drain must be made by means of pipes specially manufactured for the purpose.

(5) Connections.—The soil-pipe enters the drain without any trap intervening, and it usually forms the head of the drain. Yard gullies also connect directly with the drain. Waste pipes and rain-water pipes must never be connected with a drain, but must discharge over or near a gully which is connected with the drain. Overflow pipes from cisterns must not be connected with a drain.

(6) VENTILATION.—Drains are ventilated by providing an outlet and inlet for air. The outlet is usually the soil-pipe or some pipe similarly placed and constructed. An inlet is provided by placing a disconnecting and ventilating trap in the course of the drain just before it enters the sewer.

16. Household Refuse

DUST-BINS.—It is usually recommended that household refuse, more especially animal and vegetable refuse, should be burnt in the kitchen. In practice, however, much difficulty, not to say annoyance, may be experienced in attempting to burn refuse in a coal fire. In tenements and modern flats where gas-cooking is largely in use burning may be quite impossible. Little trouble arises from the deposit of organic refuse in a **dust-bin** provided it is removed by the local authority twice a week. In many towns only a weekly collection of refuse is made, on grounds of economy, and in such cases care must be taken by the housewife if annoyance from the smell of decomposing refuse is to be avoided, more particularly in hot weather. Each parcel of refuse should be wrapped in paper, the refuse should be closely packed in the dust-bin and shut in with a tightly-fitting cover.

There is a widespread belief that infectious diseases are associated with bad smells from cesspits, drains, middens, etc., but such belief is not based upon any scientific foundation. There is, of course, no doubt as to the extreme annoyance and discomfort which may result from bad smells, but it is not possible in the light of modern knowledge to state that infectious diseases may result from that cause alone. Infectious diseases can only arise from the invasion of the special germs which cause them, and such germs do not, so far as we know, originate in a smell. It is true generally that ill-health has often been found to be associated with conditions which give rise to bad smells such as offensive drains, closets, etc., but any particular infectious disease can only be set up by the special germs which produce it.

There are two ways, however, in which the presence of organic refuse in the vicinity of a dwelling-house may indirectly cause disease, namely, by the well-known association between refuse and flies, and also between refuse and rats.

The conditions which should be observed in connection with dust-bins are as follows:—

(1) It should be of a capacity just large enough to take a week's accumulation of refuse, but must not be too large or too heavy when full to be carried by the scavenger to the dust-cart. Otherwise the contents may have to be transferred to a basket with resulting annoyance from dust and smell and from scattering of the contents. In the case of a large house, two or more dust-bins may have to be provided.

(2) It must be movable, water-tight, of metal, and fitted with handles and a closely-fitting cover. The cover excludes rain and prevents the access of house-flies and rats. The handles facilitate removal. A round bin is more easily cleaned than is one that is square. The bin should rest on a strong rim at the bottom, otherwise the bottom will tend to become rotten and permit leakage of the contents.

(3) The dust-bin should be stored as far from the house as is convenient. The inside should be cleaned from time to time.

Ash-pits.—In the case of institutions or blocks of flats, fixed brick ash-pits or large cubical metal bins may be found convenient. In such instances great care is necessary to avoid annoyance from effluvium in hot weather. The following rules relating to ash-pits should be observed:—

(1) It must be as far as possible from the window or door of any house and must be constructed of sound and impervious material.

(2) There must be a door of convenient size, and means of emptying should be provided without carrying the contents through the house.

(3) A good lid or a water-tight roof must cover it.

(4) The floor should be three inches above the level of the ground outside.

(5) There must be no connection whatever with any drain.

(6) The contents must be completely removed on each occasion.

17. House-Flies

The house-fly is normally about a quarter of an inch in

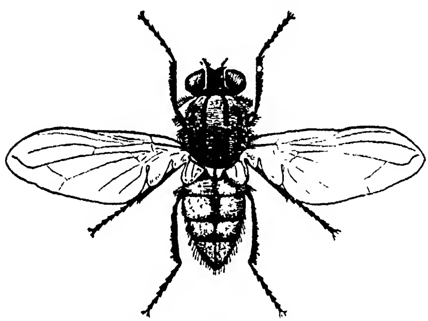

Fig. 98. House-Fly.

length. The female fly is specially attracted by fermenting horse-manure if freshly deposited, and by human excrement. The eggs, which are glistening white objects about $\frac{1}{20}$th of an inch in length, are laid in masses in warm moist animal refuse if available, but may be found occasionally in vegetable refuse.

In a day or so the eggs hatch out into small white maggots. These feed on the refuse and grow rapidly, attaining a length of about half an inch in four or five days or more. The maggots then come to rest and change into the chrysalis or pupa form. This stage lasts for a week or more and finally

the newly-hatched house-fly emerges from the pupa and is already of full size. The interval between the deposition of the egg and the emergence of the adult fly varies according to the temperature prevailing, but the shortest possible time in the English summer is about 10 days.

It may be noted that, provided house-refuse or animal manure is removed within a week after it is first deposited, there is no possibility of house-flies being released from such refuse, although it may be teeming with eggs and maggots. It is also to be noted that only fresh horse-dung is visited by the female fly for the purpose of laying eggs. Old manure heaps are no danger in this respect. Loose statements are often made on all these points.

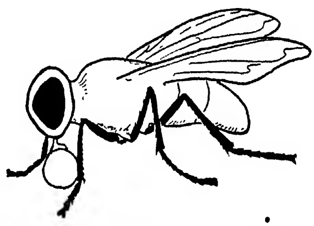

Fig. 99. FLY REGURGITATING FLUID AFTER A MEAL. (After Martin.)

HABITS.—(1) The house-fly has sticky pads on its feet which enable it to adhere to any surface. These sticky pads also become soiled with filth on which the fly settles.

(2) The house-fly frequently vomits up food which it has swallowed and so contaminates any food on which it settles.

(3) It frequently deposits its excrement, especially when it has settled on food which it likes.

(4) Its body is hairy and becomes contaminated with filth and it is, as is often seen, liable to drown in milk which it visits. This is a further source of contamination.

(5) The house-fly visits human food, refuse and excrement of all kinds indiscriminately. It may swallow disease microbes and deposit such microbes on human food, when it vomits or passes its excrement.

(6) The diseases which may be spread by the agency of the house-fly are many, but one may mention again typhoid fever and also summer diarrhoea of infants.

18. Prevention of House-Flies

The ideal method of prevention is to screen all refuse and excrement from house-flies. If this were possible, and if it were done thoroughly, house-flies would diminish. All refuse from houses, all manure from cowsheds and stables, and the contents of all privies should be removed and specially treated or utilised before any adult flies emerge. If house-flies are

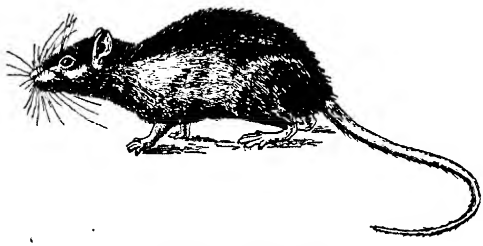

Fig. 100. Brown Rat.
(Brit. Museum Economic Pamphlet No. 8.)

found in a house they should be trapped in the many ways available, but the greatest care should be taken to keep them away from food and from settling on the faces and hands of infants.

19. The Rat

This animal is very destructive to property, especially foodstuffs of all kinds. It is also responsible for spreading at least one serious disease, namely plague, which is prevalent in many tropical countries. The commonest kind of rat is the Brown Rat, which will nest in any secluded place, but especially in disused or defective drains.

All rats are very prolific, increasing to vast numbers, unless strenuous efforts are made to combat them. The number at present in this country has been estimated at 40,000,000 and each rat consumes food worth about five shillings every year.

The measures to be adopted for dealing with rats include the following:—

(1) Proper protection of all larders, markets and stores.

(2) Keeping of all refuse in receptacles with properly fitting covers.

(3) Repairing of all defective drains.

(4) Fumigation of ships arriving in port.

(5) Systematic destruction of the animals by trapping and poisoning.

CHAPTER XXI

CONSTRUCTION OF DWELLINGS

1. Requirements for a Healthy Dwelling

In order to secure a healthy habitation, the following are the necessary requirements:—

(1) A soil suitable for building purposes.

(2) A site which is dry and an aspect which gives light and cheerfulness.

(3) A satisfactory system of sewage and refuse disposal.

(4) An adequate supply of wholesome water.

(5) Well ventilated surroundings.

(6) Good house construction.

The first four of these requirements have already been dealt with, so that only (5) and (6) remain.

2. Surroundings of the Dwelling

The open space round buildings is governed by local By-laws.

There should be at least 24 feet in front of any part of a domestic building—measured to the boundary of any land or premises opposite. Behind the dwelling there should not be less than 150 square feet of space, and in no part must the distance from the house to the boundary wall at the back be less than 10 feet.

The London Building Act, 1894, prohibited the raising of houses to a height greater than the width of the street without the consent of the London County Council, and determined the space at the back by enacting that the building shall come within a line drawn upwards at an angle of 63·5° from the rear boundary wall.

3. The Dwelling: Plan and Materials

The following points in the construction of dwellings require consideration:—(1) plan; (2) materials; (3) foundations; (4) walls, damp-proof courses, papering, etc.; (5) roof.

(1) PLAN.—The bedrooms should face south, south-east or south-west. Any room intended for storage of food should face north.

(2) MATERIALS.—The shell of a house may be constructed of (*a*) concrete, (*b*) mortar, (*c*) stone, (*d*) bricks, (*e*) wood, (*f*) plaster, (*g*) iron and (*h*) steel.

(*a*) Concrete consists of broken brick, stone and gravel mixed with cement. It is used for window-sills, foundations, artificial stone, and the modern ferro-concrete buildings. Portland cement is made from lime and dark-blue mud clay from the lias formations.

(*b*) Mortar consists of a mixture of water, lime and sand. When it is exposed to the air, the water evaporates and the lime hardens, becoming changed into carbonate of lime owing to the absorption of carbonic acid from the air.

(*c*) Sandstone, limestone, granite and other kinds of stone are used, each district utilising its own natural resources; *e.g.* granite houses in Aberdeen, limestone in Derbyshire. The durability of stone depends upon the resistance to atmospheric influences. Magnesium limestone has been largely used in this country and was recommended by a Royal Commission, after examining quarries and rocks of various kinds, for building the Houses of Parliament. Experience has shown, however, that the atmosphere of London has eaten away this stone and that many parts show extensive evidence of decay.

(*d*) Bricks are made of clay, which is ground and well mixed by a machine to render it even in texture, then moulded, dried and finally baked in kilns. The colour

depends upon the composition of the clay and the degree of burning—ordinary red bricks contain ferric oxide (Fe_2O_3); Staffordshire blue bricks have been heated to such an extent that the ferric oxide appears to be changed into black oxide (Fe_3O_4). These latter are extremely hard and much less porous than ordinary bricks.

A brick should be well shaped, and all its angles should be right angles. The edges or solid angles should be sharp and clean. It ought to weigh 5 pounds, be twice as long as it is broad, and be homogeneous in character and colour, both externally and in section. The common dimensions are 9 inches by 4½ by 3 inches. A brick can absorb as much as one pound of water, but if it absorbs more the builders regard it as "overthirsty."

Bricks are far more durable than stone, and ancient buildings all over the world testify to the superiority of art to Nature in devising a lasting building material.

Firebricks contain silica mixed with clay, are almost infusible, and are used for lining fireplaces. The best fire-clays are found under coal-beds—the presence of carbon from mineralised vegetation appears to be an improvement.

(*e*) Of the various woods, ash, beech, oak, elm, deal and pine are chiefly used. The quality of all timber depends on its rate of growth and its original position in the stem of the tree. The slower the growth and the nearer the centre of the tree, the better the specimen.

No timber can withstand alternate wetting and drying, or heat and moisture, without adequate ventilation. Under such conditions decay sets in, especially if lime be adjacent, hence the ends of house beams are liable to early degeneration. Two peculiar diseases affect timber, namely, "dry" and "wet rot," the exciting causes being fungi. Protection from decay is best secured by forcing creosote under pressure into the wood, or, in the case of external woodwork, by painting and varnishing. Ventilation of the space under the floors helps to prevent rot.

(*f*) Plaster is made of lime, sand and water, mixed with cow's hair to make it hold together better. The walls are covered with a layer of coarse plaster upon which is placed a layer of fine plaster. When dry, the plaster may be coated with colour-wash, lime-wash, paint or paper.

(*g*) Iron is used with concrete for strengthening purposes, the iron resisting the stretching force and the concrete the crushing force. In addition to this it renders the building more fire-resisting. Iron will not burn, but under the influence of great heat it will twist and buckle, thus endangering the stability of the building. No material is absolutely proof against fire, hence the advisability of using the expression "fire-*resisting*."

Galvanised iron, *i.e.* sheets of iron which have been dipped in melted zinc, is sometimes used for roofs. Iron is unsuitable material for roofing, for rust is formed and this peels off, leaving the next layer to be acted on, and thus the rust eats through. Zinc and lead oxidise when exposed to the air, but as the rust does not peel off, it forms a thin protective coating which prevents the action going deeper. It is for this reason that sheet-iron is usually coated with zinc or tin.

(*h*) Many modern houses are built on a steel framework, and recently public bodies have built houses composed entirely of this metal.

(3) Foundations.—These should be arranged (*a*) to give stability; and (*b*) to prevent damp rising to the upper part of the house.

If the house cannot be "founded on rock" owing to the depth of the surface soil, this should be dug out as far as necessary, and concrete used to form a hard substantial layer. The depth and width of this layer will depend on the height of the building and the weight to be supported.

Where houses are built on "made" soils, it is absolutely necessary to cover the whole site within the walls with a 6-inch layer of concrete, to prevent (*a*) dampness, and (*b*)

ground-air from rising into the basement, bringing with it gaseous emanations from decaying or organic matter in the soil.

The 6-inch layer of concrete should be in addition to the "bed" of concrete for the purpose of transmitting the weight of the walls to the ground.

(4) Walls, Damp-proof Course, Papering, etc.—Walls are built upon wide bases called "footings." The bottom layer of bricks in the footing should be twice the width of the wall. The concrete layer upon which the foundations rest should project laterally beyond the footings by at least 6 inches.

Walls should be at least 9 inches thick, but when a height of 25 feet or a length of 30 feet is exceeded they should be of greater thickness. Internal or partition walls should also be of brickwork, or made of some fire-resisting material, but lath and plaster partitions are frequently permitted by local By-laws.

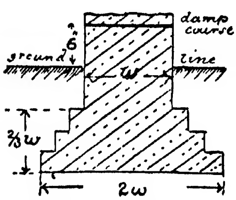

Fig. 101. Footings.

Walls are liable to become damp in three ways: first, by dampness being sucked up from the soil by the porous and absorbent bricks; secondly, by dampness passing through the face of the wall, as by driving rains; and thirdly, by dampness passing downwards through the wall from defective roofs, etc. To prevent the first cause of dampness, as already stated, the wall must stand on a bed of concrete, and a layer of some impervious material must be inserted in the wall at a height of 6 inches above the ground level, but below the floor level. Such *damp-proof courses* are made of either slates, sheet lead, hard impervious blue bricks, or vitrified glazed bricks set in cement. The slates, bricks or lead are inserted during the building of each wall.

To prevent dampness passing through the face of the wall, a covering or "rendering" of cement may be used. A pleasing effect can be produced by what is known as "pebble dash." Small pieces of flint or pebbles are thrown on to the wet cement, and when dry an impermeable indurated surface is obtained. In modern building the house walls are built double, *i.e.* an inner and an outer wall with a small space between. By these means the inner one remains dry when the outer one is wet with driving rain.

Defective rain-water guttering and pipes are the chief cause of dampness from above, downwards. The obvious remedy is repair or renewal.

From a hygienic point of view, walls are best covered internally with hard, durable distemper, or washable paint. Wall-paper harbours dirt and is difficult to clean, but it is used because of the artistic and cosy effects obtainable. For sculleries, bathrooms, larders, water-closets, etc., tiles or glazed bricks are best, as they are easy to wash down and keep clean.

For kitchens, sculleries, bathrooms, and water-closets a good varnished wallpaper is satisfactory, as it can be wiped down and cleaned. Still better, and far more durable, is the special oil-cloth for covering walls.

(5) Roofs.—For roofing, some non-absorbent material should be employed. Roofs of thatch and wood are liable to be damp and to harbour insects, and their inflammability is a source of danger. Slates and tiles are good materials; the former are light, but, being good conductors of heat, are cold in winter and hot in summer, whereas the latter, though heavy, are warmer than slates in winter and cooler in summer. Lead, zinc and copper have all been used for roofing; like slates, they are good conductors of heat, and impervious to rain.

CHAPTER XXII

INFECTIOUS OR COMMUNICABLE DISEASES. DISINFECTION

1. Infectious Diseases

Diseases which are conveyed from one person to another are called **infectious** or **communicable diseases.** The old division between "contagious" and "infectious" diseases is no longer made, as it is difficult or impossible to differentiate diseases in this way.

It is now realised that in the process of the spread of disease the personal factor predominates, *i.e.* the usual method is from one person to a second person direct. Many of the older theories with regard to the spread of disease are now abandoned owing to modern discoveries in the subject, but the methods of spread may conveniently be discussed as occurring by (1) air, (2) inanimate objects such as clothes, books, furniture, (3) water and food, (4) inoculation through a puncture of the skin, (5) living creatures.

(1) Air.—The method of spread of diseases by droplets or the scattering of infected spray from an infected person has already been explained. The diseases probably spread in this way are (*a*) smallpox, (*b*) influenza, (*c*) chickenpox, (*d*) measles and German measles, (*e*) mumps, (*f*) whooping-cough, (*g*) diphtheria, (*h*) tuberculosis. Enteric or typhoid fever may also be conveyed by air: dried-up excreta may be carried by the wind in the form of dust.

(2) Clothes, Books, Furniture.—Infected materials such as clothes, books, furniture have been held responsible for the spread of smallpox and scarlet fever.

(3) WATER AND FOOD.—The water-borne diseases are enteric or typhoid fever, cholera and dysentery. Scarlet fever and diphtheria are occasionally spread by infected milk. Milk from tuberculous cows is the chief cause of tuberculosis in children. Food infected by flies may give rise to summer diarrhoea in children.

(4) INOCULATION.—Diseases spread by inoculation are malaria, anthrax, glanders, erysipelas and tetanus.

(5) LIVING CREATURES.—Malaria is conveyed to man by means of an infected mosquito. Other mosquitoes are responsible for spreading yellow fever and sleeping sickness. Lice are concerned in the spread of typhus fever and trench fever. Common flies are frequently the cause of the spread of enteric or typhoid fever, cholera and diarrhoea. "The filthy feet of faecal-feeding flies fouling food" is an alliterative phrase which should be remembered by all.

2. Endemic, Epidemic and Sporadic Diseases

Certain terms are used to describe the method of occurrence of infectious diseases.

When an infectious disease is always found in a certain area to a greater or less extent it is said to be **endemic.** Plague is endemic in certain parts of the world, and malaria and yellow fever are endemic in certain tropical countries.

When a disease breaks out and spreads from place to place attacking a number of people, it is said to be **epidemic.** Influenza is a disease which occurs in epidemics.

Sporadic, a word meaning scattered, is applied to diseases which occur here and there in an area with apparently no connection between the cases.

Any one disease may occur in any of the above forms. Thus plague may occur sporadically, affecting a few persons here and there, may continue endemically in a certain part of a large town, or may spread epidemically over vast areas.

3. Stages Following Infection

The course of an infectious disease after infection has taken place follows the same plan in all diseases. Each disease has a definite duration. When infection has taken place there are no immediate results, and no symptoms are produced at first. The interval of time between the actual infection and the appearance of the first sign or symptom of the disease, is called the period of **incubation.** When the incubation period has elapsed the typical symptoms of the disease appear and last for a certain time, during which death may occur. If the active period of the disease is survived, recovery usually takes place, but permanent damage may have been caused.

A remarkable characteristic is that an attack of one of these diseases is rarely followed by a subsequent attack of the same disease in the same individual. In other words, an attack confers **immunity** from that disease. The chief exceptions to the above rule are diphtheria and influenza.

Infectious diseases are common in childhood because young children are specially susceptible to them. Children, as they advance in age, gradually develop increasing power of resistance which is called immunity. Immunity to most of the infectious diseases increases with age. It should, therefore, be definitely understood that children should be protected from all infection as far as possible, because every year safely passed through not only renders them less liable to contract the disease, but also tends to lessen the severity of the disease if infection should occur.

Quite regularly people who are healthy receive infection from infected people without contracting the disease. When our bodies are healthy they possess a wonderful degree of resistance to infection, and are often able to dispose successfully of an infection of this kind without suffering any harm. On the other hand, when any part of the body is not in good health, it becomes liable to a successful invasion, and if infection occurs at this time a disease may develop.

4. Microbes, Germs, Bacteria

All diseases are probably caused by minute bodies called **microbes, germs** or **bacteria.** These cannot develop anew from dead matter or from dirt or from insanitary surroundings, as each family of microbes is produced from ancestors of the same species. Tuberculosis or consumption, for example, is caused by a microbe called the tubercle bacillus, and these bacilli are capable of producing consumption and no other disease. Similarly, such diseases as smallpox, diphtheria and typhoid fever are caused by microbes which can only produce smallpox or diphtheria or typhoid fever as the case may be.

Whenever a case of these diseases occurs we may be certain that, in some way or other, the germs from a previous patient have obtained access to the infected person. Dirt and insanitary surroundings may predispose persons to give way to an attack of disease, but these conditions will not actually cause the disease, and so we must dismiss as mere foolish nonsense such statements as " smallpox is caused by dirt and insanitary conditions," or " diphtheria is caused by bad drains or bad smells."

The following are the chief points concerning some of the common infectious diseases.

5. Chicken-Pox

The mode of infection is by association with a person suffering from the disease, and the period between contracting the disease and the development of symptoms is about 14 days. The chief symptoms are:—On the first day of illness red pimples appear in crops, rapidly passing into little pearly blisters. The rash appears on the face, chest, abdomen and covered parts. The temperature is not usually high. Scabs form about the fourth day of fever, and the duration of illness is from 4 to 7 days. The duration of infectivity continues until the skin is quite clear again.

The only method of controlling the disease is by isolating all persons affected and keeping contacts under observation.

6. Diphtheria

Infection is commonly by droplets from a patient or from a carrier of diphtheria germs. Occasionally the disease may be communcated by infected articles such as pencils, by kissing or by infected milk. The possibility of the disease being due to defective drains or to cats or fowls is now disproved. The incubation period is usually two or three days, and the onset is gradual. The chief symptoms are:—(1) sore throat, (2) hoarseness and brassy cough, especially in young children, (3) fever and depression.

Mild cases of diphtheria occur often in which none of these symptoms is obvious, and the only indication is a slight redness of the throat. These cases frequently escape recognition and spread the disease.

Adults are partly immune to the disease, but a large proportion of children are susceptible to infection. It is now possible to determine with certainty whether an individual is susceptible or immune to the disease. This is done by a simple test, known as the Schick test, performed on the skin. In the case of those persons who are found to be susceptible to the disease it is now possible to confer immunity on them by a method of inoculation. Persons such as nurses, teachers and doctors who come into contact with children should be tested for susceptibility, and if necessary they should be immunised against the disease.

The germ of diphtheria is easily detected by a bacteriologist, and it is possible, by "swabbing" the nose and throat, to detect those who, although apparently well, may be carrying the disease. Similarly, diphtheria patients should never be discharged from hospital or sick-room until "swabbing" shows them to be free from infection. Contacts are swabbed to ascertain whether they are infected or not.

7. Carriers

Quite commonly persons are discovered who are harbouring the germs of some infectious disease but are not actually

suffering from the disease. Such individuals are called "carriers." Carriers of diphtheria are common. Another disease spread by carriers is enteric or typhoid fever.

8. Typhoid or Enteric Fever

Infection mainly arises from the urine or excrement of patients or carriers, and indirectly through the contamination of milk, water, food, dust or flies. The period between contracting the disease and development of symptoms is from 14 to 21 days. The onset is gradual.

The chief symptoms of typhoid are a few rose-coloured raised spots on the abdomen, with headache, lassitude, diarrhoea or constipation. The preventive measures are (1) isolation; (2) strict disinfection of all urine and stools, and everything that has touched the patient; (3) preventive inoculation; (4) destruction of flies. Soldiers or persons about to visit foreign countries should be protected against typhoid fever by inoculation.

9. Influenza

Infection is from person to person and is carried from place to place by travellers. The period between contracting the disease and development of symptoms is from 1 to 5 days, usually 2 days, and the onset is often abrupt. Prevention is by strict isolation from the earliest symptoms. Routine cleansing of mouth, throat and nose is a preventive.

10. German Measles

The mode of infection is through air or by droplets. Incubation is about 16 days. The chief symptoms are round or oval slightly raised spots, pink in colour, which appear early. The rash appears on the face, then on the chest, and gradually spreads to the whole body. The rash fades on the third day, and the duration of illness is from 4 to 5 days. Infectivity lasts one week. Prevention is by isolation, and the observation period for contacts is 3 weeks.

11. Measles

Infection is from person to person, and the period between contracting the disease and development of symptoms is about 12 days. The onset cannot be distinguished from an ordinary cold in the head. Running at the eyes and nose is an early sign. The rash does not appear till the fourth day of the disease. It consists of dull red blotches and appears behind the ears and on the forehead and face. The temperature is raised. The rash fades on the seventh day of fever. The duration of infectivity is 3 weeks. Prevention of spread is by isolation. The observation period for contacts is 3 weeks. Measles is very infectious during the catarrhal stage before the rash appears. In an epidemic children with colds should be suspected of measles. The disease causes a great number of deaths among children.

12. Mumps

Infection is by air or droplets, and the period between contracting the disease and development of symptoms is about 16 days. The chief symptoms are painful swellings behind the angles of both the jaws, with difficulty in opening the mouth. The duration of illness is 7 to 10 days. Infectivity lasts for at least a week after the swelling subsides. The prevention is by isolation. The observation period for contacts is 3 weeks. Mumps, as a disease, is not taken seriously enough by the average parent or school teacher.

13. Smallpox

Infection is spread rapidly from person to person. The period between contracting the disease and development of symptoms is 12 days. . The onset is sudden, with headache and backache. Small red pimples becoming "pocks," somewhat similar to those seen in chicken-pox, appear on the third day. The rash appears on the face and exposed parts. The temperature is high at onset, drops when the rash appears, and rises when matter appears in the pocks. Scabs form on

the ninth or tenth day and begin to fall off on the fourteenth day. The duration of illness is 14 to 21 days, and the duration of infectivity is about a month or longer if the scabs have not gone.

The preventive measures for smallpox are:—(1) all persons coming in contact with cases must be vaccinated at once; (2) isolation of the patient; (3) thorough disinfection; (4) vaccination in infancy and every seven years thereafter is the only way to ensure complete protection. The observation period for contacts is 16 days, or 8 days following vaccination, in order to confirm the vaccination as being successful.

14. Scarlet Fever

(Scarlatina is not a different and milder form of this disease, but merely another name for scarlet fever.) The mode of infection is from one person to another person mainly by means of discharges from nose, throat or ears. The period between contracting the disease and development of symptoms is 3 or 4 days. The onset is sudden. The cheeks become flushed, and there is a marked pale circle round the mouth. The rash appears on the chest. The temperature is high. The rash fades on the fifth day of fever. The duration of illness is 10 days if there are no complications, and the duration of infectivity is about 4 weeks or until the throat is quite normal and all ear or nasal discharges have ceased. Preventive measures include early diagnosis, isolation and search for carriers. The observation period for contacts is 1 week.

15. Tuberculosis

The mode of infection is twofold, either from a human subject or by drinking milk from a cow affected with bovine tuberculosis.

Tuberculosis contracted in the latter way manifests itself usually in young children, some of the resulting conditions being (1) hip-disease, (2) hunchback, (3) glands in the neck, (4) lupus of the skin, (5) abdominal consumption.

Tuberculosis may be contracted from a human source. In this case the medium of infection is droplets sprayed from nose or mouth or dried particles of sputum in the form of dust. Tuberculosis of human origin may take any form, but most usually it attacks the lungs, causing tuberculosis of the lungs, also known as **phthisis** or **consumption.** Under conditions of modern life, with numbers of consumptive persons at large and some of them careless in their habits, it is difficult for anyone to avoid infection at some time or other, but in spite of this only a small proportion of persons contract the disease. The reason for this is the fact that healthy persons are wholly or partly immune to the disease. The minority of persons who are susceptible to the disease, probably become infected at some time or other. The likelihood of this occurring is much increased by close association with a consumptive person with consequent inhalation of large numbers of germs.

Tuberculosis is a disease which is essentially curable provided that proper treatment can be commenced early and continued over a long period. Under adverse conditions, however, death nearly always results within a year or two.

Consumptives may or may not be a danger to their associates. This depends on whether the germs of tuberculosis are present in the sputum or not and how the patient behaves. If the germs are present the consumptive should make it his bounden duty to take every precaution to protect his family and associates from infection. Some simple rules are:—

(1) Sputum should be voided into disinfectant in a sputum mug and passed down the water-closet or into a paper handkerchief and burnt. No sputum should be distributed promiscuously by spitting.

(2) The patient should be specially careful in the course of coughing. A handkerchief should be held invariably in front of the mouth.

(3) The patient should sleep alone or at least in a separate bed.

(4) The patient should not kiss children or associate closely with them.

The cure or arrest of tuberculosis depends on the adoption of a calm and healthy method of life, with good food, fresh air and direct sunlight.

Tuberculosis in young children is largely due to the use of raw cow's milk. *Raw milk should not be given to children. It should be scalded, pasteurised or converted into the dried form.* The only exception is "certified" milk or Grade A (T.T.) milk (from cows free from tuberculosis). Undoubtedly a great number of children are killed or damaged every year by milk from tuberculous cows.

16. Whooping-Cough

The mode of infection is from person to person, but the disease is sometimes carried by nurses or governesses from patient to patient. The period between contracting the disease and development of symptoms is about 8 days. The onset is gradual. It commences as a common cold in which cough is usually incessant. The child coughs until it is blue in the face and then whoops. Vomiting often occurs after coughing. Fits of coughing occur four or five times daily, but in severe cases they may occur more often. Few diseases are more painful to witness. There is usually only slight fever at the commencement. The duration of illness is 6 weeks or longer, and duration of infectivity is whilst the whoop persists. Prevention is by isolation. The observation period for contacts is 21 days to allow for cases in which whoop is delayed. This is the most fatal of all the infectious complaints of children under five years old.

17. General Remarks on the Treatment of Infectious Diseases

When a child is attacked by a disease like scarlet fever or measles, if the parents cannot afford proper precautions and constant medical attendance for the patient, undoubtedly the best course is immediate removal to an isolation hospital; as

not only will this remove the danger from the family, but will secure isolation from the rest of the community and ensure the best nursing.

If the latter course is not adopted the patient must be isolated in one room and all furniture and draperies that can possibly be dispensed with should be removed from the apartment. Warmth and proper ventilation should be provided. The door of the sick-room of an infectious case is usually covered with a sheet on the outside, and the sheet is sprinkled with disinfectant, but it is difficult to see what possible use this can be, except as a danger signal.

No one should enter the room except the nurses, and they should have an adjoining room provided in which they can bathe and change into other clothing when going out for exercise.

It is best, where possible, to convert the vicinity of the room into a temporary hospital, and for all food to be deposited on a convenient table outside the room, to be taken over by the nurse.

All children, both sick and healthy, in an infected family, may have to be kept from school in accordance with the medical advice which is given.

The following periods are those during which healthy contact children should be excluded from school, dating from the last date of exposure to infection:—

Measles	3 weeks
Scarlet Fever	2 weeks
Chicken-pox	3 weeks
Smallpox	contacts re-vaccinated
German Measles	3 weeks
Diphtheria	contacts swabbed
Whooping-cough	3 weeks
Mumps	3 weeks
Typhoid Fever	contacts not excluded

These rules are modified in some districts, children who have had the disease being regarded as immune and allowed to attend school.

18. Disinfection and Disinfectants

By **disinfection** is meant the destruction of the microbes or germs of disease. The term **disinfectant** should only be applied to a substance or a process which is capable of actually destroying bacterial life. In the public mind certain odorous substances, such as tobacco smoke, scent, camphor and eucalyptus, are supposed to possess disinfecting properties, but their value in this respect is extremely small. Other substances, known as antiseptics, have the property of hindering the growth of bacteria without actually destroying them. Such substances are iodoform and boracic acid.

19. Conditions Essential to Successful Disinfection

For successful disinfection it is necessary to observe the following conditions:—

(1) A disinfectant of proved power to kill microbes must be selected.

(2) It must be used in sufficient strength or intensity.

(3) It must be given sufficient time to act.

(4) It must be given full opportunity by actual contact.

The disinfectants may be classified into (1) natural disinfectants, (2) physical disinfectants, and (3) chemical disinfectants.

20. Natural Disinfectants

Fresh air and direct sunlight have considerable power of killing microbes. The diphtheria microbe, for example, is destroyed by an hour's exposure to direct sunlight, whilst the tubercle microbe is killed even more rapidly.

For multiplication all microbes need a certain amount of moisture, and so the maintenance of a dry condition tends to check such multiplication. Thus the frequent airing of bedding and clothing, by securing desired dryness, will tend to check germs of disease. In addition the oxygen of the air tends to exercise a destructive effect on such organisms as may be present, whilst the agitation to which they are subjected mechanically dislodges and removes a proportion of the adherent microbes, which can be carried away by winds.

21. Physical Disinfectants

Heat in its various forms constitutes the simplest and most thorough disinfectant for many purposes. It may be applied in the form of fire or burning, hot air (or dry heat), boiling or steam.

(1) FIRE.—Destruction by fire is the most thorough means of disinfection, and it should always be employed in the case of articles of little value.

(2) HOT AIR.—This method is sometimes used for destroying lice, fleas and other insect pests. Unfortunately it is much more easy to damage any average material by the application of dry heat than it is to kill lice or fleas that may be in or upon it, and this is still more true in the case of a material infected with bacteria. Hot air at a temperature not injurious to most materials requires long exposure if it is to effect a disinfecting action.

(3) BOILING.—Boiling is an excellent method of disinfection and should be applied wherever possible, *i.e.* all infected materials that are not likely to be damaged by boiling should be disinfected in this way. It is specially useful for linen, towels, sputum pots, drinking utensils, plates, spoons, forks, etc.

The disadvantage of boiling is that it is apt to fix, or to render permanent, certain stains containing albuminous

material. On this account it is desirable that stained infected materials, such as soiled sheets, should be first soaked in cold water and afterwards boiled. Water in which they have been soaked must be disinfected by boiling or by the addition of some disinfectant before disposal.

(4) STEAM.—Materials which are likely to be damaged by boiling or which could not be conveniently subjected to the boiling process are disinfected by steam. In this way infected bedding, mattresses, pillows and clothing can be readily disinfected.

Steam which is given off from the surface of boiling water is ready, on the slightest cooling, to condense back again to boiling water, at the same time shrinking in volume about 1,400 times. At the time of this condensation and enormous shrinkage it gives out a great amount of heat (called latent heat), thereby raising suddenly and effectively the temperature of any article with which it is in contact. Steam ready to condense is called "saturated steam." When such steam comes in contact with the surface of a mattress it condenses, enormously diminishes in volume, and causes the temperature of the outside of the mattress to be raised to the boiling-point of water. To fill the place of the steam which has disappeared in this way more steam presses forward, goes through the outer heated layer of the mattress and repeats the process in the next layer. Then more steam presses on to the third layer, and by the rapid repetition of this process every part of the mattress is speedily penetrated and disinfected.

Steam which has been heated after it has been given off from the surface of boiling water is not ready to condense, and is called "super-heated steam." This partakes to some extent of the nature of hot air, and is not so useful as saturated steam.

22. Chemical Disinfectants

Chemical disinfectants are very numerous and are conveniently divided into (1) gaseous, (2) liquid, (3) solid.

(1) Gaseous Disinfectants.—The gaseous disinfectants in common use are sulphur dioxide, formaldehyde, chlorine and hydrocyanic acid gas.

Sulphur dioxide is a suffocating gas produced by burning sulphur. It is still used in many districts for the disinfection of infected rooms. As generally used it is not a very effective disinfectant, and it should be followed up by thorough cleansing of the room and its contents by prolonged flushing with fresh air. For the actual process of disinfection the common allowance is 3 lb. of sulphur for each 1,000 cubic feet of space to be disinfected. The complete sealing-up of the room is, of course, essential in order to retain gas in contact with the surface for several hours.

Formaldehyde is usually produced from tablets used in a special form of lamp; the gas so used is probably far less effective than a solution of the gas used in the form of a fine spray.

Chlorine gas is a useful disinfectant, but attacks and damages many materials, so that its general use is impossible.

Gaseous disinfectants were probably introduced originally with the idea of disinfecting the air of the room, but it is now realised that the air can best be dealt with by sweeping it away by opening doors and windows and flooding the room with fresh air. Disinfection of the surfaces of the walls, furniture, floors, etc., is best carried out by means of a spray of disinfectant liquid.

(2) Liquid Disinfectant.—The liquid disinfectants consist of solutions or emulsions of certain chemical disinfectants in water. Cresol, cyllin and lysol form emulsions with water and are effective disinfectants. Carbolic acid in the form of one part acid dissolved in 20 parts of water is also effective.

For disinfecting woodwork and floors, a very dilute solution (1 in 1,000) of corrosive sublimate (mercuric chloride) is useful, but for general purposes it has serious disadvantages.

Formalin, which is a 40 per cent. solution of formaldehyde gas in water, gives a useful disinfectant liquid when it is

mixed with 50 times its bulk of water. This solution is often used in the form of a spray for disinfecting rooms. For disinfecting typhoid excreta a useful disinfectant is a 10 per cent. solution of formalin in water. The stools are mixed with an equal quantity of the disinfectant.

An excellent disinfecting liquid for all kinds of purposes is made by adding two ounces of bleaching powder to a gallon of water and thoroughly shaking the mixture. The mixture has to be made daily as it does not keep well.

(3) Solid Disinfectants.—Solid disinfectants, as such, serve very little useful purpose. Carbolic powder and such like materials are sometimes sprinkled about offensive surfaces, and serve to hide a disagreeable smell by covering it with the smell of carbolic. Bleaching powder is a powerful disinfectant but does not act in its dry condition.

PRONUNCIATION OF TERMS

Numerous suggestions have been made that it would be helpful to many readers to have a guide to the pronunciation of scientific and anatomical terms. The following may be useful:—

WORD	PRONOUNCED
Abdomen	Ab-doe′-men
Amylase	Am′-il-aze
Aqueous	Ake-we-us
Bicuspid	By-kus′-pid
Caecum	See′-cum
Caffeine	Kaf′-een
Cartilage	Kar′-til-age
Casein	Ka′-zeen
Cerebellum	Ser-ee-bel′-lum
Cerebrum	Ser′-ee-brum
Cervical	Ser-vy′-kal
Chlorine	Klor′-ine
Choroid	Kor-oid
Chyme	Kyme
Cilia	Sil′-e-ah
Coccyx	Kox′-ix
Cochlea	Kok′-le-ah
Colon	Ko′-lon
Cornea	Kor′-nee-a
Corpuscle	Kor-puss′-sl
Cranium	Kray′-nee-um
Cyllin	Sil-lin
Diaphragm	Di′-af-ram
Duodenum	Du-o-dee′-num
Epithelial	Ep-ith-ee′-le-al
Eustachian	U-stay′-kee-an

Word	Pronounced
Facet	Fass′-et
Femur	Fee′-mur
Fibula	Fib′-u-la
Foramen	For-ay′-men
Hydrochloric	Hy-dro-klor′-ik
Ileo-caecal	Ill-e-o-see′-kal
Larynx	Lar′-inks
Lipase	Lye-pase
Lymphatic	Lim-fat′-ik
Medulla	Med-ul′-la
Metacarpal	Metta-kar′-pal
Metatarsals	Metta-tarsals
Mitral	My-tral
Oesophagus	Ee-sof′-a-gus
Ossicle	Oss′-ik-al
Oxyhaemoglobin	Oks-ee-hee-mo-glo′-bin
Pancreas	Pan′-kree-as
Parotid	Par-ot′-id
Pericardium	Perry-kard′-ee-um
Peripheral	Per-if′-er-al
Peritoneum	Perry-tun-ee′-um
Phalanges	Fal-an′-gees
Pharynx	Fare′-inks
Phthisis	Thy′-sis
Protoplasm	Pro′-tow-plassem
Ptyalin	Ty′-a-lin
Pubic	Pew′-bik
Pulmonary	Pul′-mon-aree
Pyloric	Py-lor′-ik
Pylorus	Py-lorus
Retina	Ret′-inn-er

Word	Pronounced
Sacrum	... ... Say′-crum
Salivary	... ... Sal′-ive-a-ree
Scapula	... ... Skap′-u-la
Sclerotic	... ... Skler-ot-ik
Sebaceous	... ... See-bay′-shus
Serum	... ... See′-rum
Synovial	... ... Sy-no′-vee-al
Theine	... ... Tee-in
Theobromine	... ... The-o-bro′-min
Tibia	... ... Tib′-e-er
Trachea	... ... Trak-ee′-er
Tricuspid	... ... Try-kuss′-pid
Tuberculosis	... ... Tu-berk-u-lo′-sis
Tympanum	... ... Tim′-pan-um
Ulna	... ... Ull′-nah
Ureter	... ... U′-re-ter
Venous	... ... Vee′-nuss
Villi	... ... Vil′-lie
Visceral	... ... Viss′-e-ral
Vitreous	... ... Vit′-re-uss

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